AD-A050 498 NORTHROP CORP HAWTHORNE CALIF ELECTRONICS DIV F/G 17/7
AN/BRN-7 COMPUTER PROGRAM SPECIFICATION. VOLUME X. CONTROL-INDI--ETC(U).
OCT 73 N00039-73-C-0209
UNCLASSIFIED NORT-73-48-VOL-10 NL

1 OF 2
AD A050498



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```
Initial:  Reset TF MKR = true
          Cold Start MKR = true; exit
```

VOL. X.

NORTHROP

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- ☐ This submittal applies to AN/BRN-7 (Submarine Ω) only.
- ☐ This submittal applies to AN/SRN-( ) (Hydrofoil Ω) only.
- ☒ This submittal applies to both AN/BRN-7 and AN/SRN-( ).

CONTRACT NO: N00039-73-C-0209

PROGRAM NAME: AN/BRN-7

CDRL No: A01D, A01E, A01F

Title of CDRL: Computer Program Design Specification
Computer Subprogram Design Document
Data Base Design Document

Title of Doc: AN/BRN-7 Computer Program Specification
NORT 73-48
Volume 2 thru 13

Date: 1/16/74

Initial Submittal: [X]

Resubmittal: [ ]

Release	APS 1-16-74
Authentication	

ACCESSION for
NTIS White Section X
DDC Buff Section ☐
UNANNOUNCED ☐
JUSTIFICATION
Per DDC Form 50
BY on file
DISTRIBUTION/AVAILABILITY CODES
Dist. AVAIL. and/or SPECIAL
A

Prepared by: System Integration Unit
Orgn. Name

A4734 X574
Orgn. No. and Ext.

Approved by:

Norman C Clark
Supervisor of Preparing Orgn.

Bill Dyer
Program Mgr.

C J Oman
Proj. Engr./Proj. Mgr.

FORM 6512 (2-72)

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AD-A050498

NORT 73-48

AN/BRN-7 COMPUTER PROGRAM SPECIFICATION

Volume X

CONTROL-INDICATOR SUBPROGRAM DESIGN

October 12, 1973

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Approved by

G. W. Hauser
Director, Engineering
Navigation Department

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Volume X
of the
AN/BRN-7 OMEGA COMPUTER
PROGRAM SPECIFICATION

Volume	
I	Performance Specification
II	Design Specification
III	Synchronization Subprogram Design
IV	OMEGA Processing Subprogram Design
V	Tracking Filter Subprogram Design
VI	Kalman Filter Subprogram Design
VII	Propagation Prediction Subprogram Design
VIII	Navigation Subprogram Design
IX	Executive Subprogram Design
X	Control-Indicator Subprogram Design
XI	Built-in Test Subprogram Design
XII	Common Subroutines Subprogram Design
XIII	Appendix

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SECTION 1

SCOPE

1.1 IDENTIFICATION

Volume I, Submarine OMEGA Computer Program Performance Specification, defines the functional requirements for the Submarine OMEGA Computer Program which is used by the AN/BRN-7 OMEGA Navigation Set. The Navigation Set and the OMEGA program together comprise the Submarine OMEGA Navigation System. The tape which defines the computer program is entitled AN/BRN-7 Navigation Program.

Volume II, Submarine OMEGA Computer Program Design Specification, allocates the functional requirements of Volume I to the computer routine and subprogram level.

This volume describes the subprogram designated as Control-Indicator which uses the abbreviations of CI and DP in the program listing (Volume XIII).

1.2 CONTROL-INDICATOR SUBPROGRAM TASKS

The Control-Indicator Panel is the interface between the operator and the OMEGA System. The tasks of the Control-Indicator Subprogram are to:

a) Provide input/output procedures for the insertion of the following data:

- Submarine present position
- Date and time
- Data for fixed destination
- Data for point of intercept (rendezvous)
- Velocity and heading source selection
- Inputs (Station Deselection)

b) Provide procedures for processing and updating, on operator demand, the following:

- Submarine present position
- Positional variance estimate
- Date and time
- Submarine velocity and heading
- Submarine corrected velocity and track angle
- Range and bearing to fixed destinations
- Time enroute and course to fixed destinations

- Heading and velocity of moving destination
- Time enroute and course to moving destination
- Position of point of intercept (rendezvous)
- Station-to-station LOP
- Relative OMEGA signal coherency
- Relative OMEGA signal strengths
- Status of sync or signal strengths
- Bite failure Status
- Number of tracking filter dumps

c) Provide procedures for processing and updating continuously (once/second) the following:

- Rendezvous position update
- Rendezvous time update

d) Provide input/output procedures for the display of all information above.

SECTION 2

APPLICABLE DOCUMENTS

a) Submarine OMEGA Computer Program Performance Specification (Volume I of the Submarine OMEGA Computer Program Specification)

Applicable Sections:

3.2.3 Computer Input/Output
3.2.4 Operation
3.2.5 Detailed System Operations
3.3.15 Control-Indicator Panel Requirements
3.3.16 Built-in-Test Programs

b) Submarine OMEGA Computer Program Design Specification (Volume II of the Submarine OMEGA Computer Program Specification).

c) NORT 71-41, NDC 1070 Macro Assembler, May 1971

d) NORT 68-115A, Detailed Description of NDC-1070 Computer Instructions, Revision A, February, 1970.

e) NORT 69-87A, NDC-1070 Flow Chart Program, User's Manual.

SECTION 3

REQUIREMENTS

There are two primary processors managing the functions of the control-indicator procedures:

a) PANEL MAIN is a non-Ω-task which will process those control-indicator routines selected by the operator. These routines will be processed once per second after the selected routine has been flagged and the input data has been stored in appropriate registers.

b) PANEL INPUT is the interrupt routine which provides the interface between the operator action and the PANEL MAIN routine. It manipulates the panel lights, checks the validity of operator procedures, tracks the procedures when a series of operator actions are required, and puts data in the proper form for processing.

Because of the quantity of control-indicator flow diagrams the description and the diagrams themselves were separated into two parts. Section 3.1 is devoted to the description of the PANEL MAIN flow diagrams, and is followed by the PANEL MAIN flow diagrams. Section 3.2 does the same for the PANEL INPUT routine.

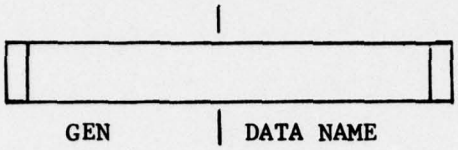
3.1 PANEL MAIN DESCRIPTION

3.1.1 Reference Labels to Flow Diagrams

The code used to reference the particular block in the flow diagrams is as follows: The first number is the page number found in the upper right corner of the diagrams. This will be followed by a slash sign (/) to separate the page number from the block designator. The designator will either be a mnemonic label (e.g., TEST SYNC), a local label indicated by a dollar sign ($), or an integer. The two types of labels reference the particular information block, on the given page, to which the label is attached. The integer number, n, means that the referenced block is the n^{th} block from the top of the page; p8/3 would refer to page 8 and the third information designation down.

Finally, the label p1/$ 2 + 3 refers to page 1, and the 3^{rd} information block after the label $ 2. All references to page numbers will indicate the flow diagram pagination in the upper right corner of the flow diagram.

There is a reference to a subroutine which is indicated as:



This refers to the Display Conversion subroutine on flow diagram pages 78-82. The meaning is that the data designated as DATA NAME is processed by the Display Conversion subroutine.

3.1.2 Description of PANEL MAIN Routines

3.1.2.1 PANEL MAIN (Pages 1 through 3)

This routine processes all data inserted through the control indicator panel and generates all data displayed on the panel. Figure 1 is a general flow diagram of the PANEL MAIN routine. It is a non-OMEGA task that is executed each second. If the panel is in a Panel Test condition (mode neg) then Panel Test is continued upon entry; if the panel is in the quiescent (mode 0) state then the routine is exited; if in the display mode (mode 1) then the routine enters the display program at every tenth entry (once per second); if not in display then it must be in the insert mode which means that the ACCEPT button has just been depressed to complete a procedure and the data displayed on the panel should be processed.

Table 1 lists all PANEL MAIN routines and the flow diagram page at which they can be found.

a) INPUTS (Station Selection)

When INPUTS is depressed then the stations selected can be changed, as well as the Navigation mode (AUTO OR MAN) can be selected.

PANEL MAIN

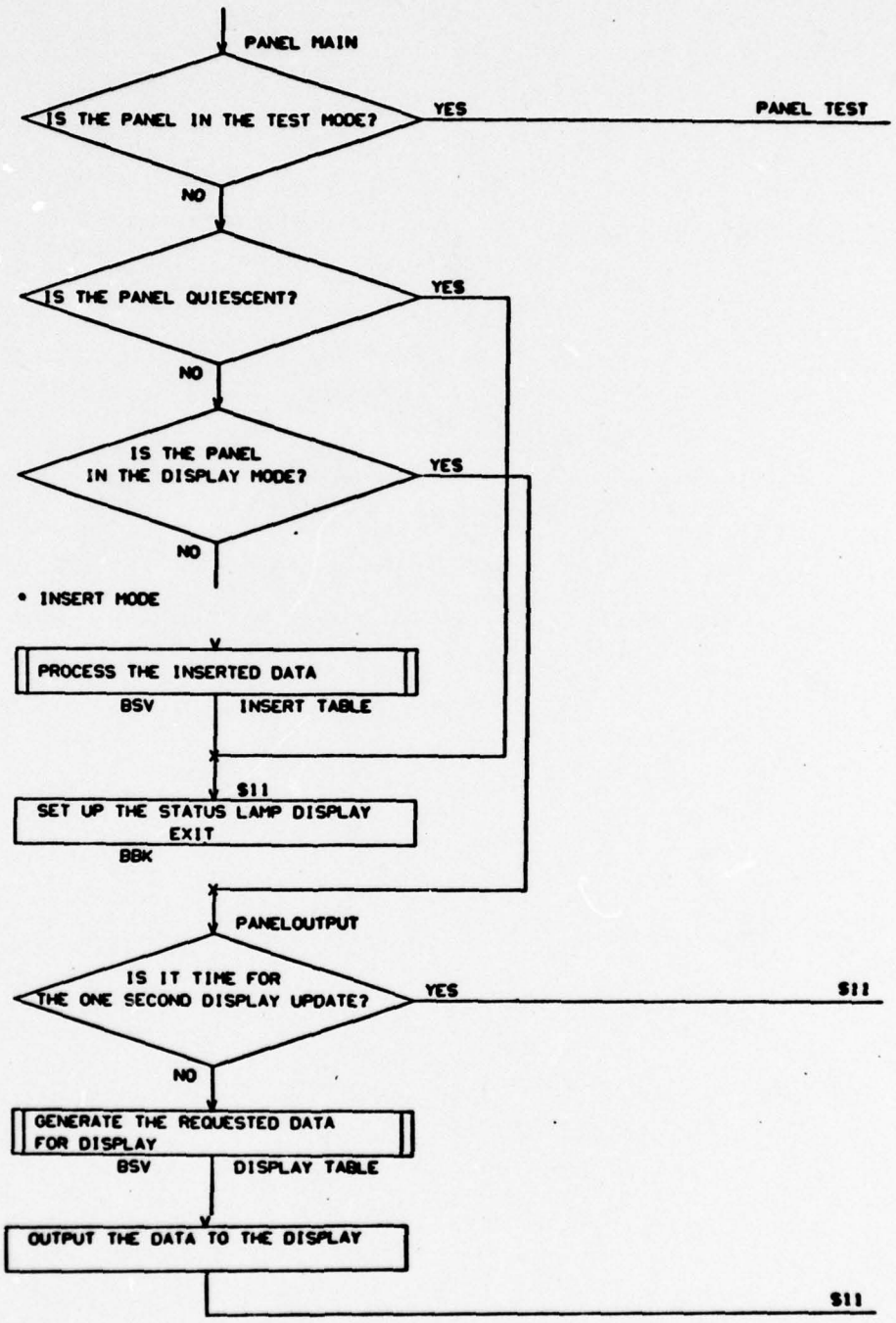


FIGURE 1

TABLE 1

ROUTINE	PAGE(S)	ROUTINE	PAGE(S)
PANEL	1-3		
Insert Routines		Display Routines (Cont.)	
INPUTS (Station Selector)	4-5	Range & Bearing BNG/RNG	24
Date-Time (DT/GMT)	6-9	CSE-ETE	25
Manual Velocity (MAN H/S)	10	Coherency (COH)	26-31
Position Insert (POS)	11-13	Date-Time (DT/GMT)	32-35
Moving Destination (RZ))		LOP	36-39
Position	14	NCTR	40-41
Velocity, Heading	15	MAN H/S	42
Display Routines		INPUTS	44
Display Program	16-17	MAN H/S RZ	45
Position (POS)		CAL H/S	46
Destination	18	AUTO H/S	47
Intercept (0-9)	18		
Rendezvous Craft (RZ)	19	Blanks	48
SHIP	19		
STATUS	20-22		
Variance (VAR)	23		

b) DATE Time Insert (pages 6-9)

p6/1 through 5

Whenever the operator inserts a new Date and Time the Kalman routine must be informed via a marker bit so that it can appropriately reinitialize its parameters. If the time is inserted in response to the illuminated ENT-T indicator, indicating a system restart, then set:

$$\delta V_2 = \delta V_3 = 0$$

COLD START MKR = True

$$C_{pos} = \sigma^2(0.5)$$

p7/1 through p9/1

The inserted Month and Day are saved for the Propagation Prediction season index determination. Then the inserted DATE and TIME is converted to a single number representing the current time. This conversion must account for the number of days in a month and leap years.

The present value of the TIME register is subtracted from the inserted current time to give the time GMT(o) at turn-on.

c) Manual Velocity Insert (page 10)

Convert speed from an integer number of knots to feet/second. Convert direction from integer number of degrees to an angle scaled pi radians

$$\psi \text{ insert} = 180 - (\text{insert} - 180)/180$$

d) Position Insert (pages 11-13)

For an inserted moving destination position, the position vector is computed. However, the inserted position of the submarine is treated in two different ways as a function of whether it is a Present Position insertion used to initialize the system or whether it is a Position Fix used to update the system.

The first position insert is treated as a Present Position. The R_{ij} matrix is initialized, using the inserted latitude and longitude, and the appropriate class of fix marker is set for the Kalman Routine, provided the existing Present Position is not accepted without change. Subsequent position inserts before sync is obtained are treated as a first insert. The ENTER PP lamp is turned off. All other position inserts are treated as Position Fixes. These are utilized as a Kalman measurement input and are incorporated into the system via Kalman

Processing. The Kalman inputs are computed. These include the position differences between the system and the inserted values in the North and East directions, the extraction matrix elements for each of these measurements and the noise scaler. Also, a marker is set to inform the Kalman routine that a position measurement has been made.

p11/$ 7, 1,2,3

If lat-long for Fixed Destination they are stored; if for submarine, continue.

p11/$72

ARG2 contains POS CLASS = i i = A, B, C

$C_{POS} = \sigma^2 (\delta \text{ POS INSERT})_i$; where

i = A, B, C

i	δ Pos Insert
A	0.5 n miles
B	5.0 n miles
C	20.0 n miles

Test First Insert = true? (i.e., are ENT - POS or SYNC indicators illuminated?) yes, go to p12/$17
no, go to p13/$73 unless Kalman has not been initiated yet, in which case go to p12/$16.

p12/$16+1

Use common subroutine Position Matrix Computation, which is called by $8, to computer R_{ij} matrix. NOTE: This is shown in the flow diagram PANEL MAIN $8.

$r_{11} = \sin \lambda_o$
$r_{12} = \cos \lambda_o \cos L_o$
$r_{13} = \cos \lambda_o \sin L_o$
$r_{21} = 0$
$r_{22} = -\sin L_o$
$r_{23} = \cos L_o$
$r_{31} = \cos \lambda_o$
$r_{32} = -\sin \lambda_o \cos L_o$
$r_{33} = -\sin \lambda_o \sin L_o$

were N = $>\lambda_o$ positive S = $>\lambda_o$ negative

E = $>L_o$; W = $>360° - L_o$

Initial: Reset TF MKR = true
Cold Start MKR = true; exit

p13/$73+1

Position Update. Use subroutine MAKE LAT LONG, page 88, to compute the following:

$$\lambda_{A/C} = \tan^{-1} \frac{r_{11}}{\left(r_{13}^2 + r_{12}^2\right)^{\frac{1}{2}}}$$

$$L_{AC} = \tan^{-1} \left(\frac{r_{13}}{r_{12}}\right)$$

p13/$73+2

$$\delta P_N = \left(\lambda_{A/C} - \lambda_o\right) K_{RD}$$

$$\delta P_E = (L_{A/C} - L_o) \cos \lambda_{A/C} K_{RD}$$

p13/$73 + 3,4

Test : $1s\sqrt{\delta P_N^2 + \delta P_E^2}$ >72 n miles?

Yes: Go to p12/$16
No: Continue
Notify combination filter, exit.

e) Moving Destination, Position Insert (Page 14)

The operator may insert up to ten fixed locations for which a great circle course may be desired, based upon the position of the submarine at the time the data is desired. To do this the latitude (λ) and longitude (L) and the reference number (i; 0-9) are stored in the table of destination points. Thus, where λ_D, L_D represent the current position of the second submarine (or vehicle),

$$\lambda_D = \lambda \qquad 0 \leq i \leq 9$$
$$L_D = L$$

Subroutine Lat/Long scaling is on page 86.

f) Moving Destination, Velocity-Heading Insert (Page 15)

To interpret the flow diagrams the following equivalences must be noted:

Flow Diagram	Equations
RZ POS	$\vec{D}_E$
VEL VECTOR	$\hat{V}_E$
BETA	$\vec{\beta}_E$
K	D_{RAD}

Convert λ_D, L_D to position $\vec{D}_E$

$$\vec{D}_E = (D_{E1}, D_{E2}, D_{E3}) \text{ where } D_{E1} = \text{Sin } \lambda_D$$
$$D_{E2} = \text{Cos } \lambda_D \cos L_D$$
$$D_{E3} = \text{Cos } \lambda_D \sin L_D$$

Obtain unit velocity in earth-fixed coordinates

$$\hat{V}_E = (V_{E1}, V_{E2}, V_{E3}) \text{ where } D_{RAD} = (D_{E2}^2 + D_{E3}^2)^{1/2}$$
$$V_{E1} = D_{RAD} \cos \alpha_D$$
$$V_{E2} = \frac{-D_{E1} D_{E2}}{D_{RAD}} \cos \alpha_D - D_{E1} \sin \alpha_D$$
$$V_{E3} = \frac{-D_{E1} D_{E3}}{D_{RAD}} \cos \alpha_D + \frac{D_{E2}}{D_{RAD}} \sin \alpha_D$$

Obtain great circle route β with unit velocity of moving destination

$$\vec{\beta}_E = \vec{D}_E \times \hat{V}_E$$

$$= (\beta_{E1}, \beta_{E2}, \beta_{E3}) \qquad \beta_{E1} = D_{RAD} \sin_D$$

$$\beta_{E2} = -\frac{D_{E2} D_{E1}}{D_{RAD}} \sin\alpha_D + \frac{D_{E3}}{D_{RAD}} \cos\alpha_D$$

$$\beta_{E3} = -\frac{D_{E3} D_{E1}}{D_{RAD}} \sin\alpha_D - \frac{D_{E2}}{D_{RAD}} \sin\alpha_D$$

3.1.2.2 Display Routine

P16/Panel Output

The first three information blocks represent the ten-counter which slows the Display rate to once per second. Nine times out of ten the Display Program branches to P2/Panel main $11 which is the routine exit.

Otherwise, the Hold Marker is tested. If 0 then the requested variables are transferred for display. If positive then branch to the display table.

P17/Table $4

One of these thirteen entries are selected for display. These thirteen entries will be described following.

P17/Table $4 + 1.
This is the output generator. Upon completion the 10-counter is reset and the Display routine exits.

a) Position Display (Pages 18 - 19)

The diagrams combine all the position displays as indicated below.

1) Destination (λ_{Di}, L_{Di}, i = 0, 1,...9)

λ_{Di}, L_{Di} are stored in memory and displayed on command.

2) Intercept (λ_{PI}, L_{PI})

The SLOW routine includes the RZ-Time update subroutine which computes the vector quantity $\vec{P}_{IE}$. The Display Intercept position computes

$$\lambda_{PI} = TAN^{-1} \frac{P_{IE1}}{\left[P_{IE2}^2 + P_{IE3}^2\right]^{1/2}}$$

$$L_{PI} = TAN^{-1} \left(\frac{P_{IE3}}{P_{IE2}}\right)$$

3) Rendezvous Craft

The position, course and speed of the moving destination were previously initialized, then tracked with time updates every second. The position updating process for position is described in paragraph e, Moving Destination, and indicated as:

$$D_E = (D_{E1}, D_{E2}, D_{E3})$$

To convert to latitude and longitude:

$$\lambda_D = TAN^{-1} \frac{D_{E1}}{\left[D_{E2}^2 + D_{E3}^2\right]^{1/2}}$$

$$L_D = TAN^{-1} \frac{D_{E3}}{D_{E2}}$$

The Subroutine indicated by GEN LONGITUDE DISPLAY, P18/4, is the Display Conversion Subroutine on Page 78.

4) Submarine (Present Position)

The current submarine position as defined by latitude and longitude will be extracted from the R_{ij}'s. If the HOLD button has been depressed the R_{ij}'s will be those stored upon its depression. The following calculations must be made.

$$\lambda_{pp} = \text{TAN}^{-1} \frac{r_{11}}{\left(r_{12}^2 + r_{13}^2\right)^{\frac{1}{2}}}$$

If $\lambda_{pp} \geq 0$ then left projection = N

$\lambda_{pp} < 0$ then left projection = S

$$L_{pp} = \text{TAN}^{-1} \frac{r_{13}}{r_{12}}$$

If $0 \leq L_{pp} < 180°$ then right projection = E

$180° \leq L_{pp} < 360°$ then $L_{pp} = 360° - L_{pp}$

and right projection = W

b) Status Display (Page 20-22)

This Display will provide the operator with information relative to the progress of synchronization, information on relative signal strengths from the burst phase measurement process, or information about failures in BIT Routines (See Volume XI)

If in synchronization then the

quantity $\frac{\Delta C}{C_D} = \frac{C(1st) - C(2nd)}{C_D}$

is displayed with appropriate scaling

If not in synchronization then the

Q_m burst from each station on the frequency selected is displayed on a scale from 0 to 9, ie, one digit for each station.

c) POS VAR (Page 23)

Upon depression of the illuminated VAR button, the current estimate of positional variance from the combinational filter will be displayed. This is obtained from the covariance matrix:

$$PV = \frac{(P_{11} + P_{22})^{\frac{1}{2}}}{\sqrt{2}} \text{ converted to n miles}$$

d) Range and Bearing (Page 24)

The angular distance between the submarine and the destination point is computed. The distance is then achieved by multiplication of the earth radius.

The angle between the R_3 vector and the destination vector D_i is computed by taking appropriate "dot" products with the R_2 and R_3 axes to generate the sin and cos of this angle. The actual bearing angle is computed from this angle with respect to the R_3 axis and θ_p.

If the HOLD button has been depressed, then the information used in this computation is that which was stored in its depression.

The bearing to destination will be displayed to a tenth of a degree in the left numeric readout. The range to destination will be displayed in nautical miles on the right.

1) Test HOLD MRK true = >use r_{ij}*

false = >use r_{ij}

2) $\hat{D}_i = \sin\lambda_{Di}\ \hat{E}_1 + \cos\lambda_{Di}\cos L_{Di}\ \hat{E}_2 + \cos\lambda_{Di}\sin L_{Di}\ \hat{E}_3$

3) $\Psi_{Di} = -\theta_p - \tan^{-1}\left(\dfrac{-\hat{D}_i \cdot \hat{R}_2}{\hat{D}_i \cdot \hat{R}_3}\right)$

where $\theta_p = \tan^{-1}\left(\dfrac{r_{21}}{r_{31}}\right)$

4) $R_{Di} = R_o \tan^{-1}\left(\dfrac{\left|\hat{D}_i \times \hat{R}_1\right|}{\hat{D}_i \cdot \hat{R}_1}\right)$

e) ETE-CSE Display (Page 25)

The course is defined exactly the same as Bearings, and therefore the computation is the same (Refer to Display Range and Bearing, paragraph d, above).

The estimated Time Enroute is computed by computing the range and dividing it by the component of craft velocity in that direction.

If the HOLD button has been depressed, then the information used in this computation is that which was stored on its depression.

1) Test HOLD MRK True, then use r_{ij}^*, V_{ci}^*

False, then use r_{ij}, V_{ci}

2) Ψ_{Di}, R_{Di} from Range and Bearing Display routine

3) $V_c = \left[V_{c3}^2 + V_{c2}^2\right]^{1/2}$

Divide R_{Di} by 100 to obtain minimum acceptable submarine velocity, V_{cmin}

Is $V_{cmin} \leq V_c$

If so

$$ETE_i = R_{Di}\left[V_{c3}^2 + V_{c2}^2\right]^{-1/2}$$

If not

ETE_i = 100 hrs

f) Coherency Display (Pages 26 - 31)

There are two coherency displays implemented by either DISPLAY STATUS COH or simply DISPLAY COH. STATUS COH provides a display of predicted phase measurement (left display) based on the systems calculated position and time which may then be compared to the actual measured phase contained in the tracking filters (right display). The display is as shown below:

	XX	XX	XX	XX	XX	XX	
Frequencies	10 1/5	11 1/3	13 3/5	10 1/5	11 1/3	13 3/5	Freg.
	Predicted			Measured (same as COH Display)			

Upon depression of DISPLAY COH buttons either six two-digit coherency values will be displayed in the registers or three four-digit numbers. These values are derived from either a station-base, or base-base pair respectively and all three frequencies (the particular station has been preselected).

P26/POP8

The first six information blocks make a distinction between STATUS COH, phase difference navigation and, essentially, rho-rho navigation. The computer program does both - the Submarine uses phase-difference.

P26/$10 through P27

In the following subscript i represents the station selected, k represents the base selected and j represents the frequency (j=1, 2, or 3).

Let ϕ_{ikj} represent the phase difference value in the tracking filter for i and k on j, less the integer lane count.

COH_{ikj} represent the coherency value for same,

θ_{3ikj} represent the propagation corrections for same.

Then $COH_{ikj} = \phi_{ikj} - \theta_{3ikj} - (t_i - t_k) \frac{\phi_{kj}}{10}$ j=1, 2, 3

where j=1=10.2 KHz
=2=13.6 KHz
=3=11-1/3 KHz

P28/1 through P29/2
FOR COH
Display in the first pair of digits of left indicator:

$COH(11.3\ -10.2) = COH_{ik3} - COH_{ik2}$

Display in the second pair of digits of left indicator:

$COH(13.6\ -11.3) = COH_{ik2} - COH_{ik3}$

Display in the third pair of digits of left indicator:

$COH(13.6\ -10.2) = COH_{ik2} - COH_{ik1}$

Display in the first pair of digits of right indicator: COH_{ik1}

Display in the second pair of digits of right indicator: COH_{ik3}

Display in the third pair of digits of right indicator: COH_{ik2}

FOR STATUS COH

Display predicted values in left register and measured values in right register.

P29/$20 through P31

If yes - Display in first four digits of left indicator: ϕ_{kk1}

Display in last pair of left and first pair of right: ϕ_{kk2}

Display in last four digits of right indicator: ϕ_{kk3}

g) Display Date and Time (Pages 32 - 35)

This routine, though elaborate, presents the current date and time to the operator. The majority of operations involve shifting and counting. The function is to take present value of TIME register and add to GMT(0) to obtain the current real time in GMT. This number is converted to YEAR, MONTH, DAY, HOURS MINUTES and SECONDS for display.

h) Display LOP (Pages 36 - 39)

This procedure will be iterated twice for each of the station-difference pairs selected by the operator.

1) The station difference pair desired by the operator will be presented in the normal chart order. Let (m-n) represent the LOP difference desired. Let j represent the frequency selected by the operator. LOP's using the base station are corrected for the base station to non-base station time delay contained in the tracking filters.

Test: Does base-station = n?

Yes: Then set $LOP_{mnj} = \hat{\phi}_{mnj} - (t_m - t_m) \frac{\hat{\phi}_n}{10} + 900$

No: Continue

2) Test: Does base-station = m?

Yes: Then set $LOP_{mnj} = -\left[\hat{\phi}_{nmj} - (t_n - t_m) \frac{\hat{\phi}_m}{10}\right] + 900$

No: Continue

3) Set $LOP_{mnj} = \hat{\phi}_{mkj} - \hat{\phi}_{nkj} + 900$

EXIT: Display LOP_{mnj}

i) Display NCTR (Pages 40 - 41)

The illuminated NCTR enables the operator to display the number of tracking filter dumps to the combinational filter for each station and verifies that this data is displayed. The 12 digits of the display are partitioned in units of four digits: four for the station-base or base-base pair selected on each frequency. On each frequency the first two digits will represent the total number of times that the data from the tracking filter selected has been used by the combinational filter to update position. The third digit is N_{Dj}, the N counter from that tracking filter, and the fourth digit is σ^2_{Dj}, the phase variance of the data in the tracking filter.

1) $NCTR_{Dj} = NCTR_{ikj}$ from the combinational filter

2) $N_{Dj} = N_{Dikj}$ from the tracking filters selected

3) $\sigma^2_{Dj} = \sigma^2_{\emptyset\emptyset_{ikj}}$

In the above, the subscript D indicates a displayed variable set

σ^2_{Dj} = nearest integer number in cec^2 if $\sigma^2_{Dj} > 9\ cec^2$ then set $=9\ cec^2$

j) Display MAN H/S, (Page 42)

1) INPUTS Display (Page 44)

This routine outputs previously inserted station data and the navigation mode.

m) RZ H/S Display (Page 45)

This routine is associated with the time update equation in paragraph (f) insert for Point of Intercept, which should be referenced by the reader for derivations.

Let $\vec{\beta}_E$ = BETA = great circle route of moving destination defined in earth-fixed coordinates

$\vec{D}_E$ = RZPOS = present time-updated position of moving destination

α_D = heading of moving destination.

Then

$$\alpha_D = \text{Tan}^{-1}\left(\frac{\beta_{E1}}{(\beta_{E2}D_{E3} - \beta_{E3}D_{E2})}\right), \text{ convert to degrees}$$

The velocity display will be that which was last inserted by the operator for the moving destination.

n) CAL H/S Display (Page 46)

The OMEGA velocity is computed by taking the square root of the sum of the squares of the two craft velocity components.

The Track Angle is computed by finding the heading of the velocity vector relative to system axis and then using this in conjunction with system heading to yield the heading with respect to North.

If the HOLD button has been depressed, then the information used in this computation is that which was stored on its depression.

1) Test HOLD MRK True => use r_{ij}^*, V_{ci}^*

False => use r_{ij}, V_{ci}

2) $V_c = (V_{c2}^{\ 2} + V_{c3}^{\ 2})^{1/2}$

3) $\psi_V = \tan^{-1} \frac{V_{c2}}{V_{c3}} - \theta_p$ and convert to degrees

where $\theta_p = \tan^{-1} \frac{r_{21}}{r_{31}}$

o) AUTO H/S Display (Page 47)

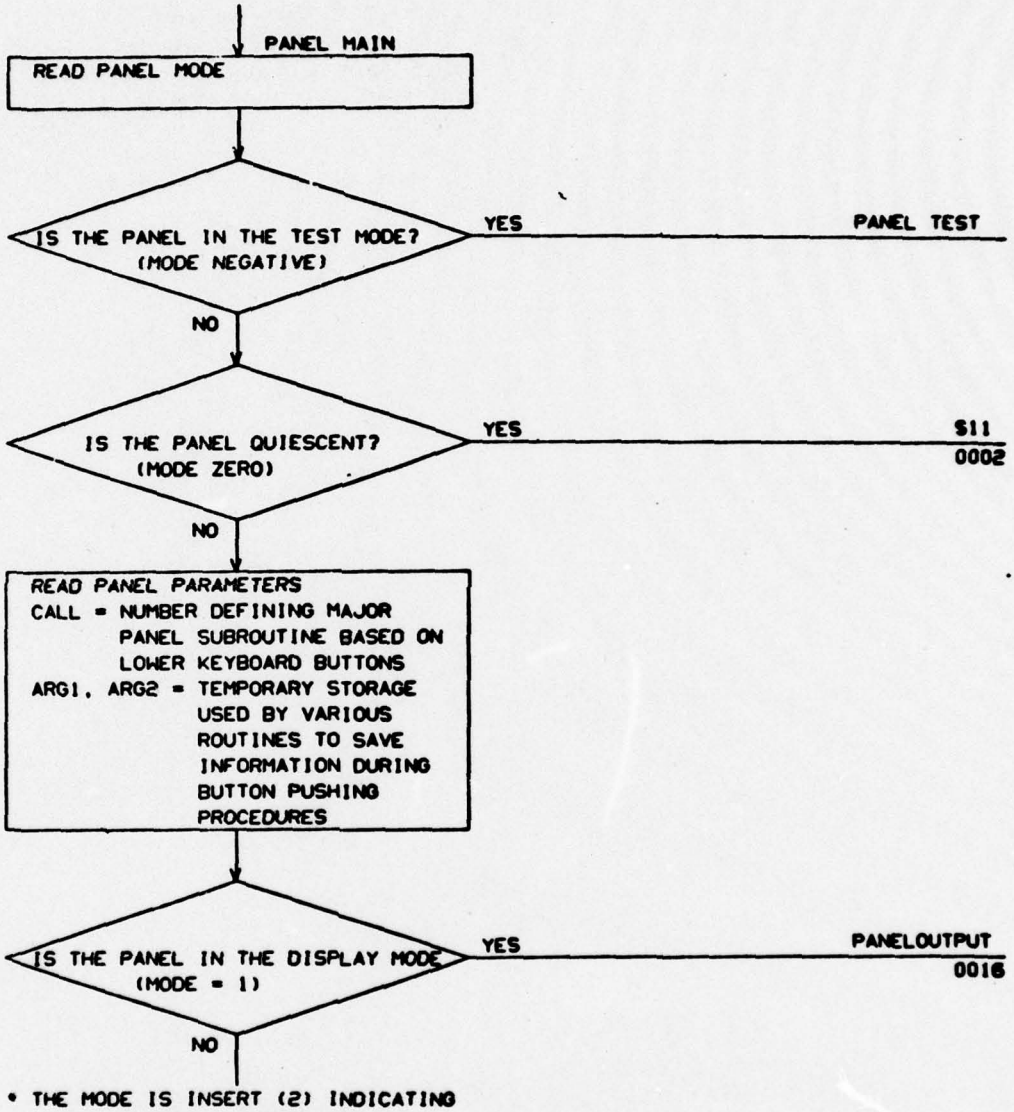
The current submarine velocity is V_{TAS} and is obtained from Velocity and Heading Processing. It is a smoothed value of the E.M. Ship's Log input and is displayed on the left numeric readout to tenths of knots.

The current submarine heading is designated ψ_A and is either the manual input or the smoothed value of the Mark 19 Repeater input, depending upon the velocity and heading mode in use. It is converted from radians to degrees and displayed on the right numeric readout.

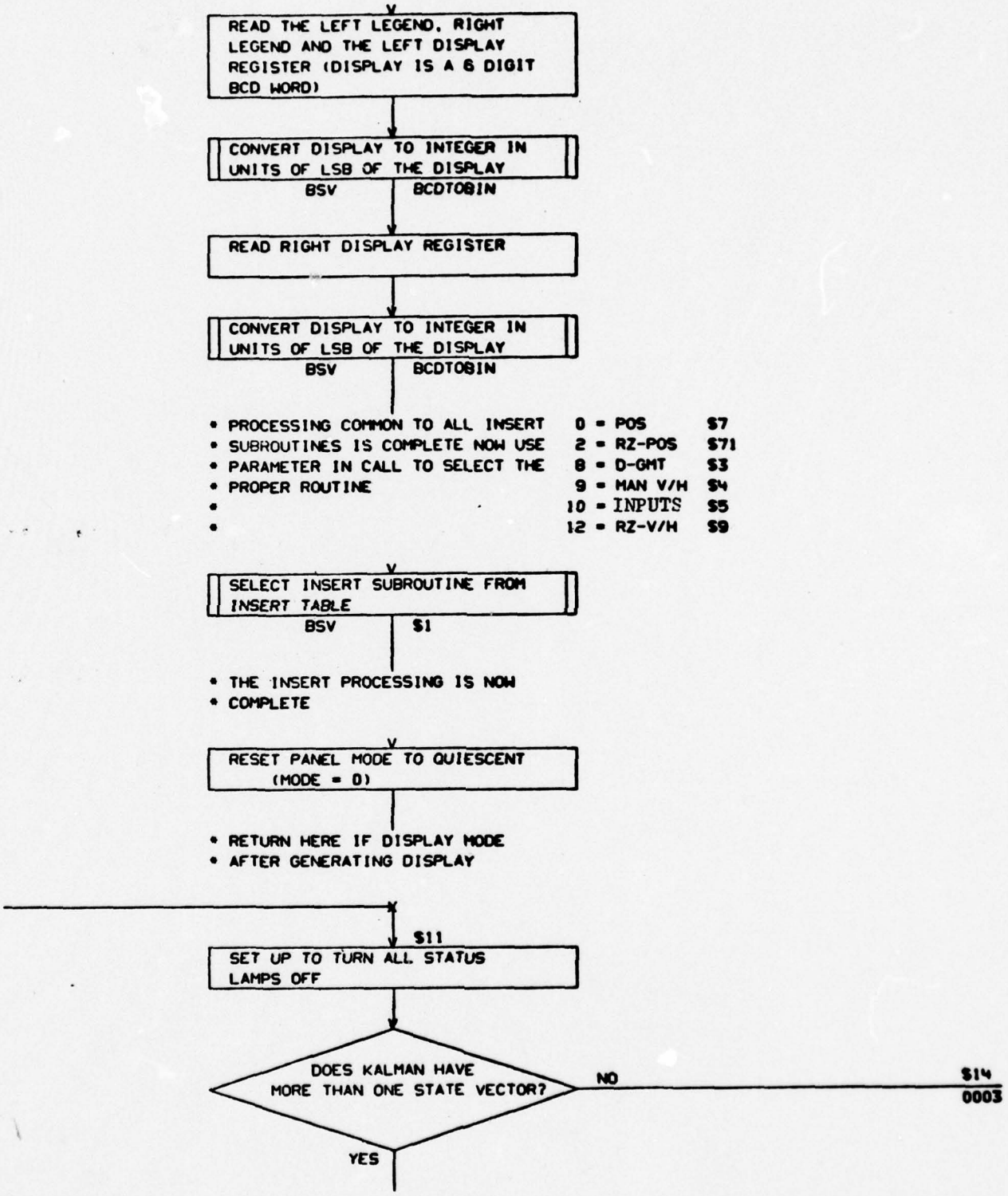
p) BLANKS (Page 48)

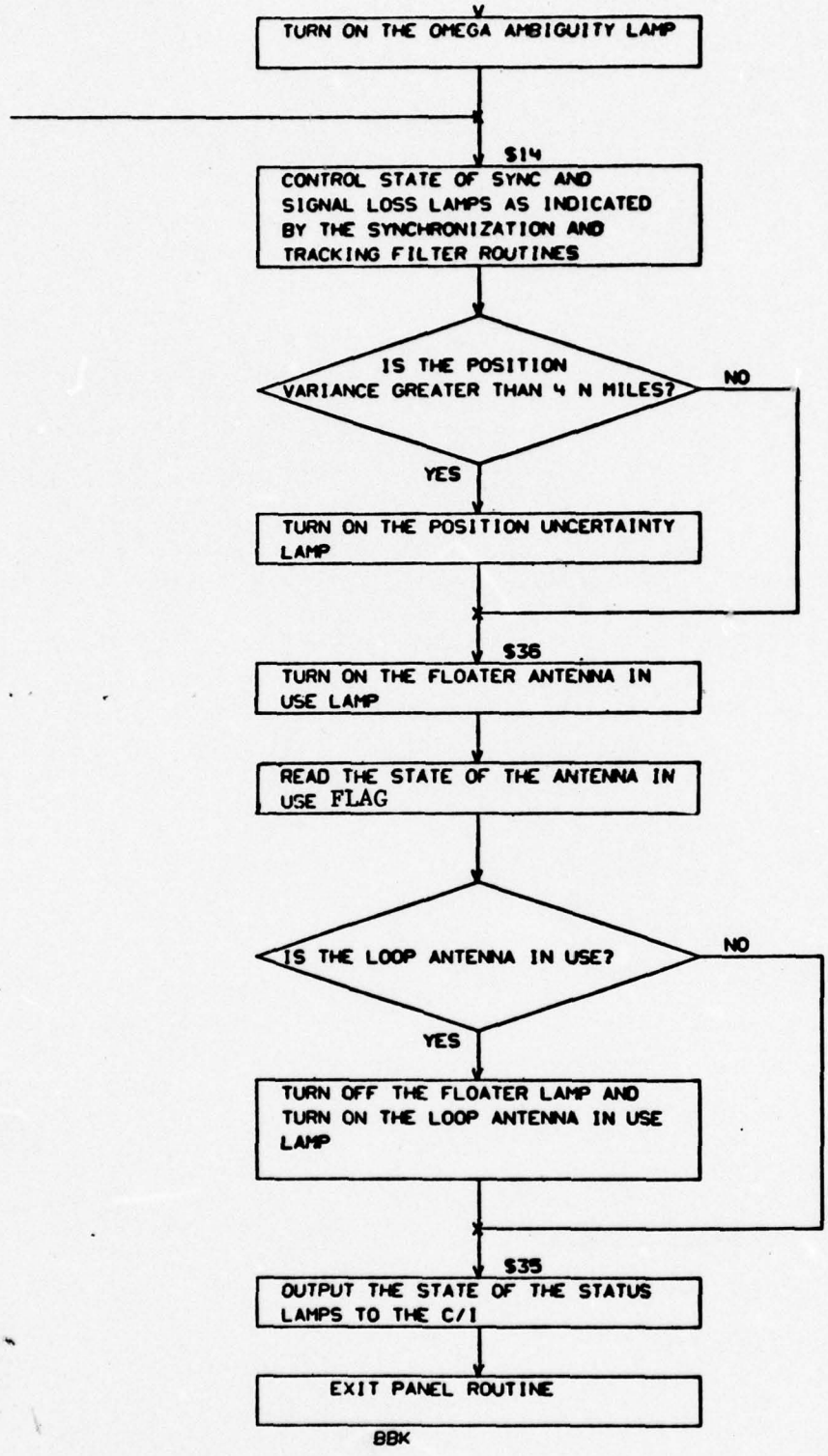
This sub routine is used by other factors to setup the display registers. Used by STATUS display (P22/$10), POS VAR (P23).

```
•                          PANEL MAIN
•
• THIS ROUTINE PROCESSES ALL DATA INSERTED THROUGH THE CONTROL INDICATOR
• PANEL AND GENERATES ALL DATA DISPLAYED ON THE PANEL.  IT IS A NON
• OMEGA TASK THAT IS EXECUTED 10 TIMES A SECOND.
•
```

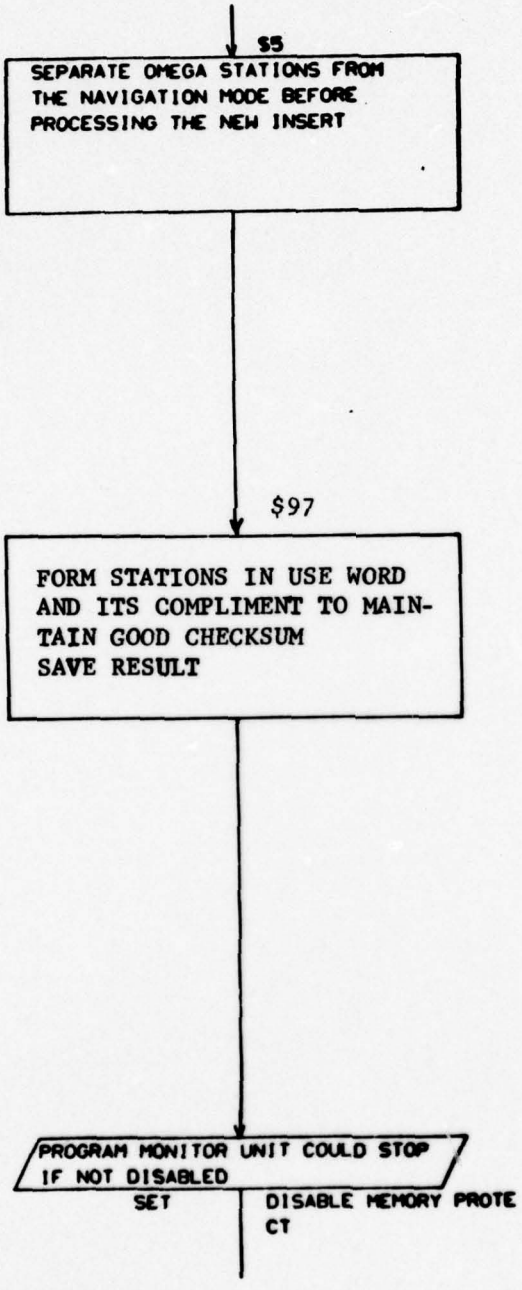


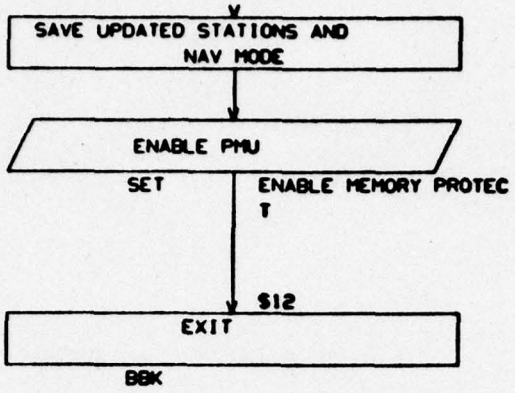

```
• THE MODE IS INSERT (2) INDICATING
• THAT THE ACCEPT BUTTON HAS JUST
• BEEN DEPRESSED TO COMPLETE A PRO-
• CEDURE AND THE DATA DISPLAYED ON
• THE PANEL NOW SHOULD BE PROCESSED
```


READ THE LEFT LEGEND, RIGHT LEGEND AND THE LEFT DISPLAY REGISTER (DISPLAY IS A 6 DIGIT BCD WORD)
CONVERT DISPLAY TO INTEGER IN UNITS OF LSB OF THE DISPLAY
BSV
BCDTOBIN
READ RIGHT DISPLAY REGISTER
CONVERT DISPLAY TO INTEGER IN UNITS OF LSB OF THE DISPLAY
BSV
BCDTOBIN
• PROCESSING COMMON TO ALL INSERT
• SUBROUTINES IS COMPLETE NOW USE
• PARAMETER IN CALL TO SELECT THE
• PROPER ROUTINE
•
•
0 = POS $7
2 = RZ-POS $71
8 = D-GMT $3
9 = MAN V/H $4
10 = INPUTS $5
12 = RZ-V/H $9
SELECT INSERT SUBROUTINE FROM INSERT TABLE
BSV
$1
• THE INSERT PROCESSING IS NOW
• COMPLETE
RESET PANEL MODE TO QUIESCENT (MODE = 0)
• RETURN HERE IF DISPLAY MODE
• AFTER GENERATING DISPLAY
$11
SET UP TO TURN ALL STATUS LAMPS OFF
DOES KALMAN HAVE MORE THAN ONE STATE VECTOR?
NO
$14
0003
YES

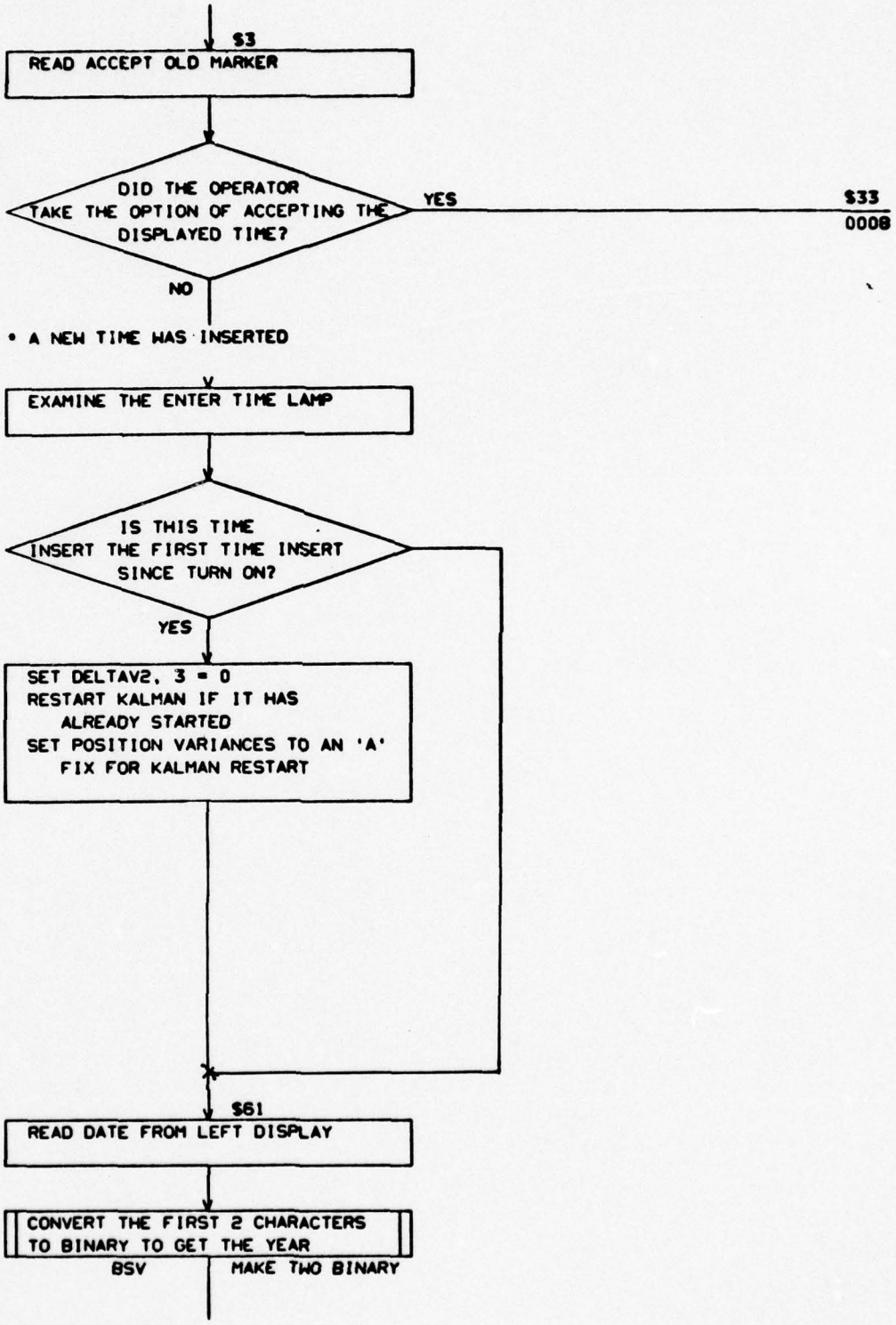

TURN ON THE OMEGA AMBIGUITY LAMP
$14
CONTROL STATE OF SYNC AND SIGNAL LOSS LAMPS AS INDICATED BY THE SYNCHRONIZATION AND TRACKING FILTER ROUTINES
IS THE POSITION VARIANCE GREATER THAN 4 N MILES?
NO
YES
TURN ON THE POSITION UNCERTAINTY LAMP
$36
TURN ON THE FLOATER ANTENNA IN USE LAMP
READ THE STATE OF THE ANTENNA IN USE FLAG
IS THE LOOP ANTENNA IN USE?
NO
YES
TURN OFF THE FLOATER LAMP AND TURN ON THE LOOP ANTENNA IN USE LAMP
$35
OUTPUT THE STATE OF THE STATUS LAMPS TO THE C/I
EXIT PANEL ROUTINE
BBK

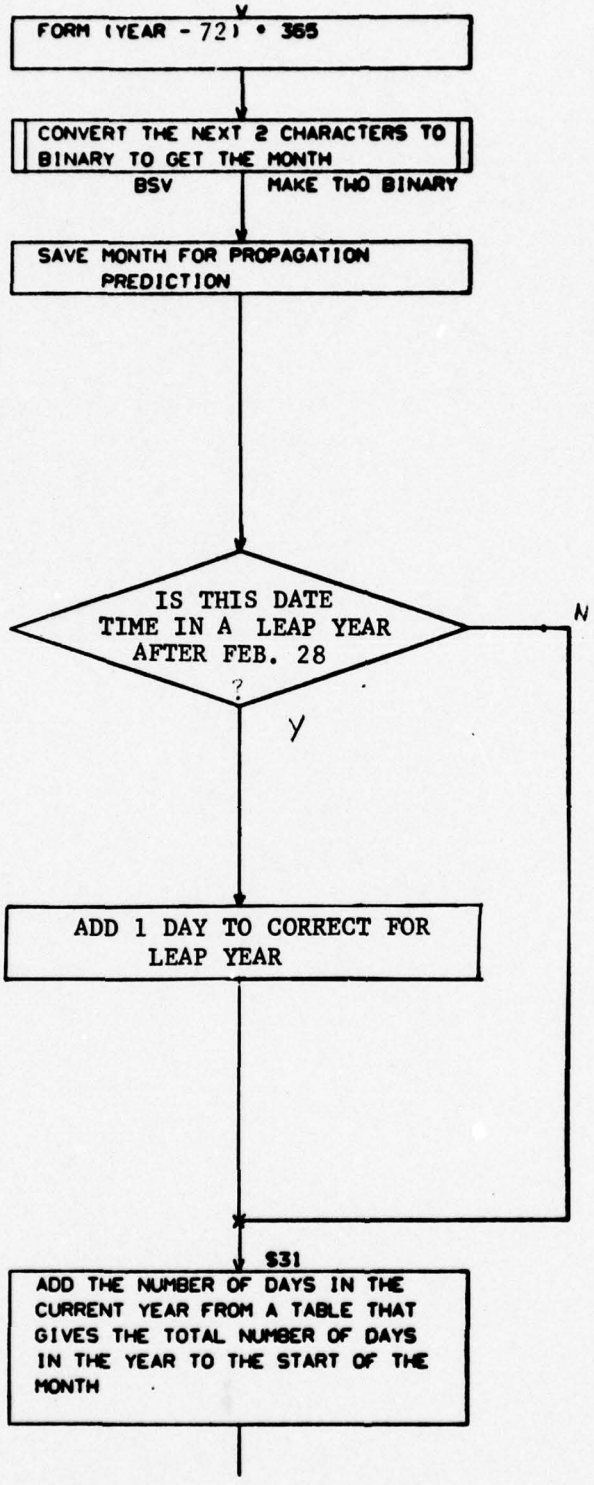
• OMEGA DR INSERT
•
• NOTE - A SINGLE 16 BIT WORD
• DEFINES THE CURRENT
• LIST OF STATIONS AVAIL-
• ABLE AND NAV MODE THAT
• HAVE BEEN SELECTED BY
• THE OPERATOR

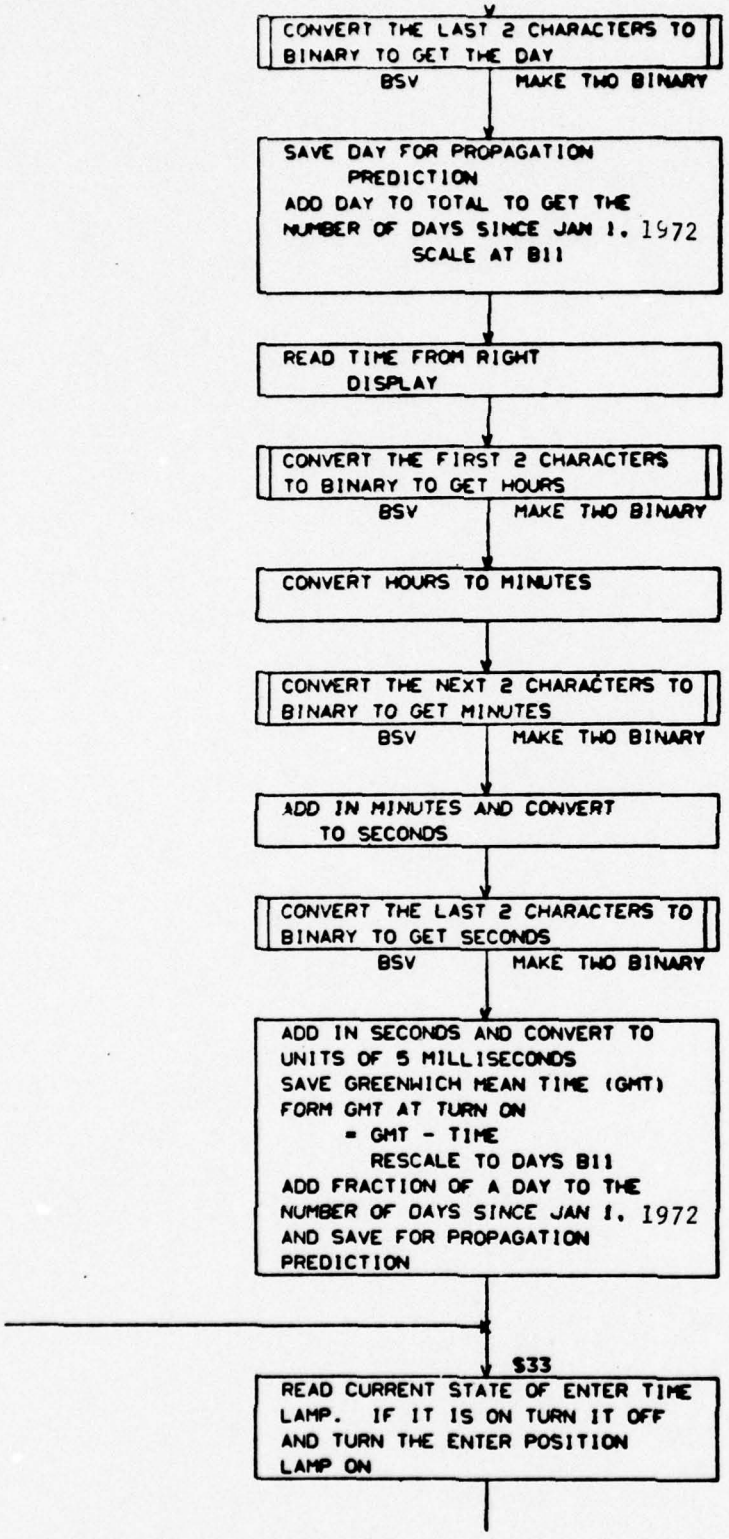


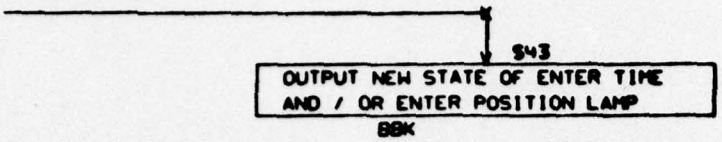

SAVE UPDATED STATIONS AND NAV MODE
ENABLE PMU
SET
ENABLE MEMORY PROTECT
$12
EXIT
BBK

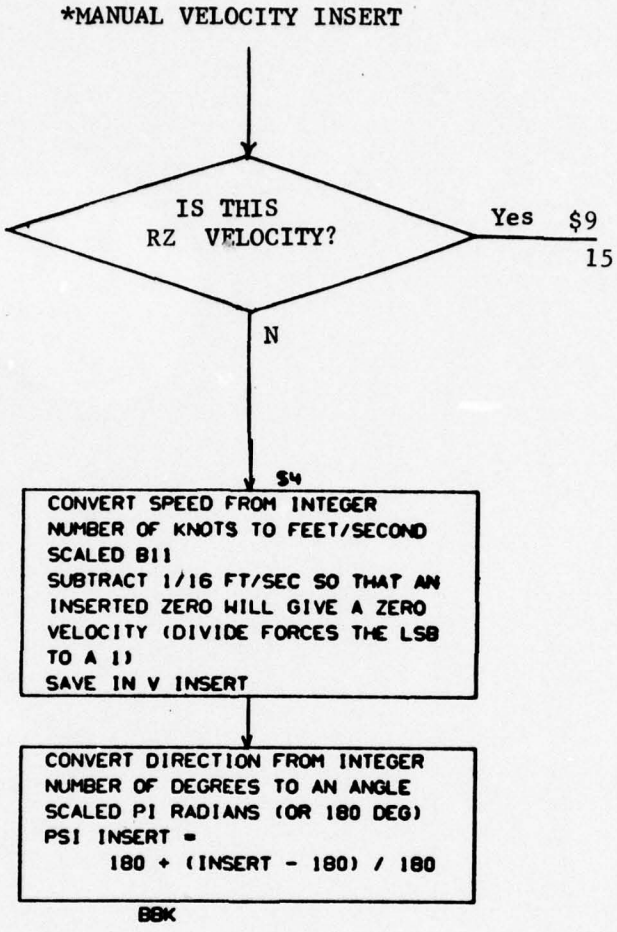
• DATE TIME INSERT



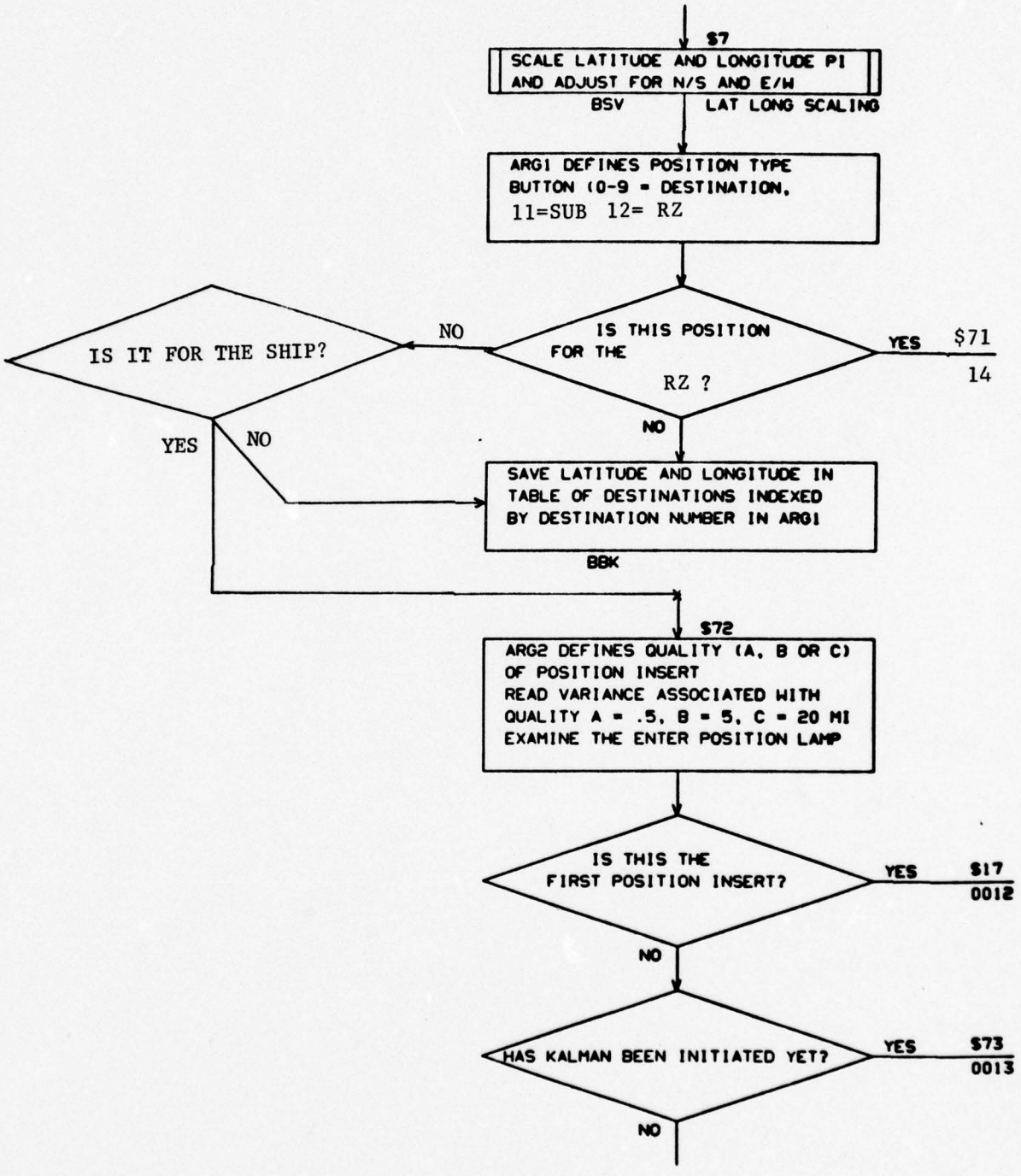

FORM (YEAR - 72) * 365
CONVERT THE NEXT 2 CHARACTERS TO BINARY TO GET THE MONTH
BSV
MAKE TWO BINARY
SAVE MONTH FOR PROPAGATION PREDICTION
IS THIS DATE TIME IN A LEAP YEAR AFTER FEB. 28 ?
N
Y
ADD 1 DAY TO CORRECT FOR LEAP YEAR
$31
ADD THE NUMBER OF DAYS IN THE CURRENT YEAR FROM A TABLE THAT GIVES THE TOTAL NUMBER OF DAYS IN THE YEAR TO THE START OF THE MONTH

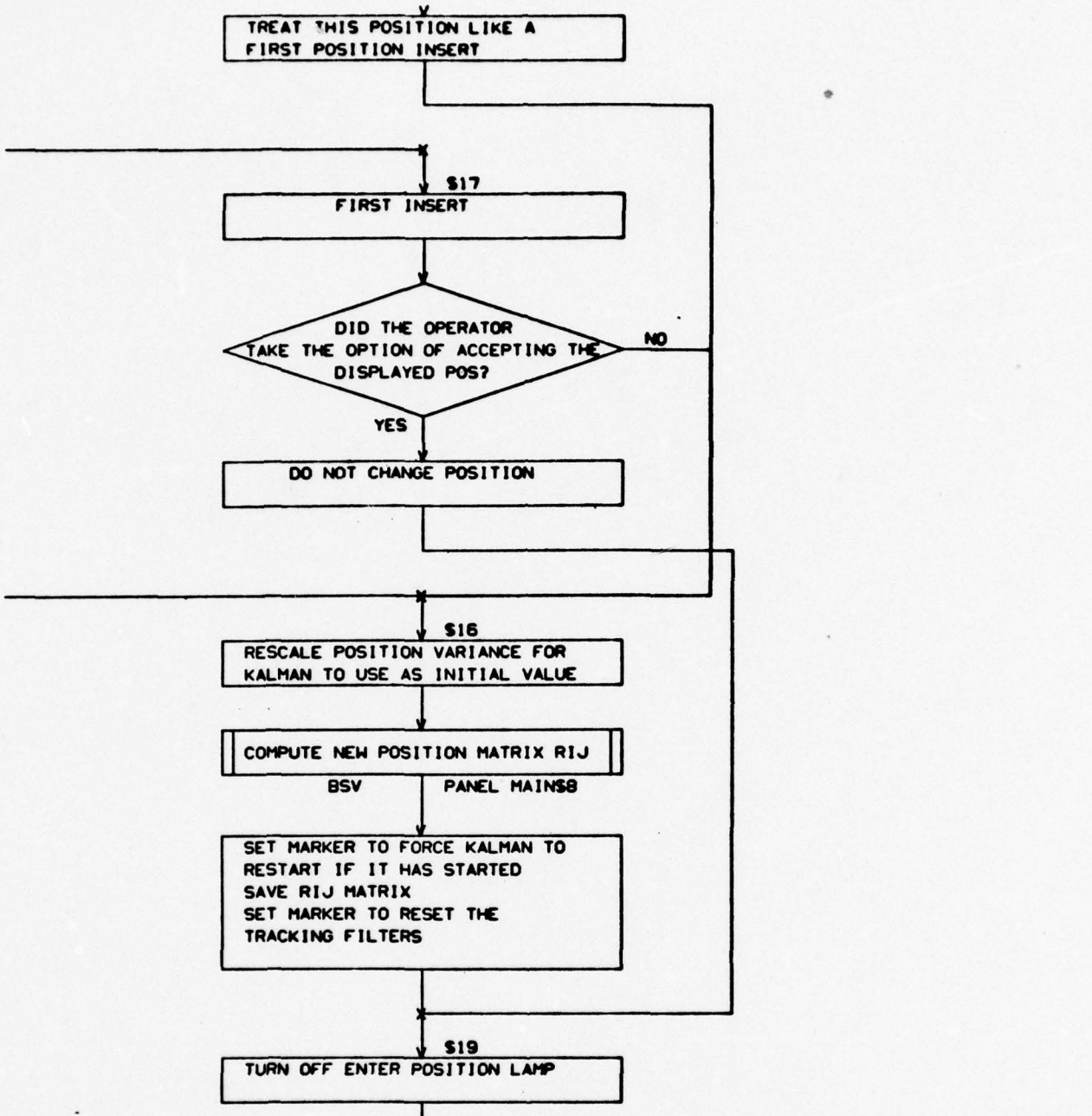

CONVERT THE LAST 2 CHARACTERS TO BINARY TO GET THE DAY
BSV
MAKE TWO BINARY
SAVE DAY FOR PROPAGATION PREDICTION
ADD DAY TO TOTAL TO GET THE NUMBER OF DAYS SINCE JAN 1, 1972
SCALE AT B11
READ TIME FROM RIGHT DISPLAY
CONVERT THE FIRST 2 CHARACTERS TO BINARY TO GET HOURS
BSV
MAKE TWO BINARY
CONVERT HOURS TO MINUTES
CONVERT THE NEXT 2 CHARACTERS TO BINARY TO GET MINUTES
BSV
MAKE TWO BINARY
ADD IN MINUTES AND CONVERT TO SECONDS
CONVERT THE LAST 2 CHARACTERS TO BINARY TO GET SECONDS
BSV
MAKE TWO BINARY
ADD IN SECONDS AND CONVERT TO UNITS OF 5 MILLISECONDS
SAVE GREENWICH MEAN TIME (GMT)
FORM GMT AT TURN ON
= GMT - TIME
RESCALE TO DAYS B11
ADD FRACTION OF A DAY TO THE NUMBER OF DAYS SINCE JAN 1, 1972 AND SAVE FOR PROPAGATION PREDICTION
$33
READ CURRENT STATE OF ENTER TIME LAMP. IF IT IS ON TURN IT OFF AND TURN THE ENTER POSITION LAMP ON


S43
OUTPUT NEW STATE OF ENTER TIME
AND / OR ENTER POSITION LAMP
88K

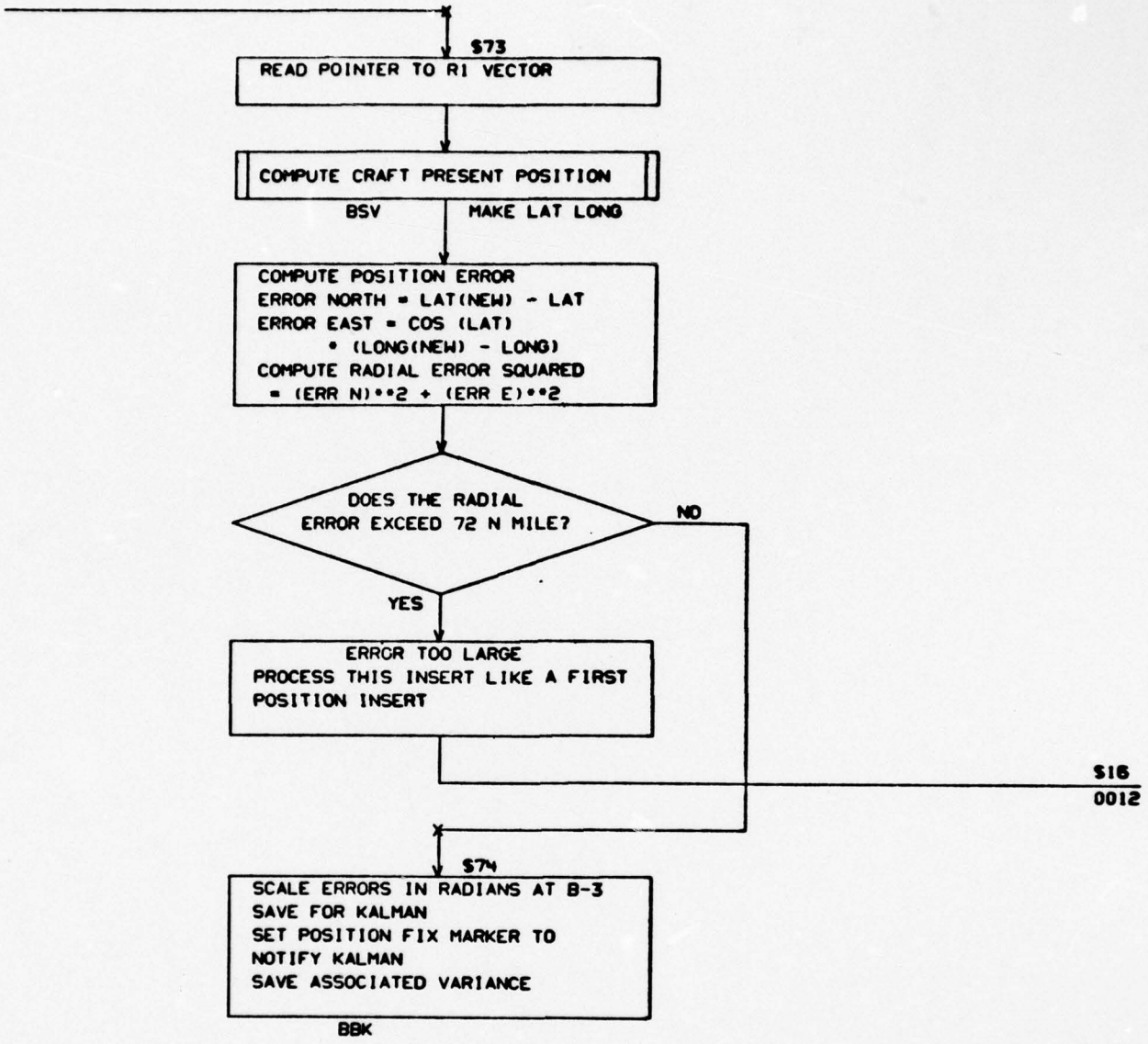

*MANUAL VELOCITY INSERT
IS THIS
RZ VELOCITY?
Yes
$9
15
N
$4
CONVERT SPEED FROM INTEGER
NUMBER OF KNOTS TO FEET/SECOND
SCALED B11
SUBTRACT 1/16 FT/SEC SO THAT AN
INSERTED ZERO WILL GIVE A ZERO
VELOCITY (DIVIDE FORCES THE LSB
TO A 1)
SAVE IN V INSERT
CONVERT DIRECTION FROM INTEGER
NUMBER OF DEGREES TO AN ANGLE
SCALED PI RADIANS (OR 180 DEG)
PSI INSERT =
180 + (INSERT - 180) / 180
BBK

• POSITION INSERT

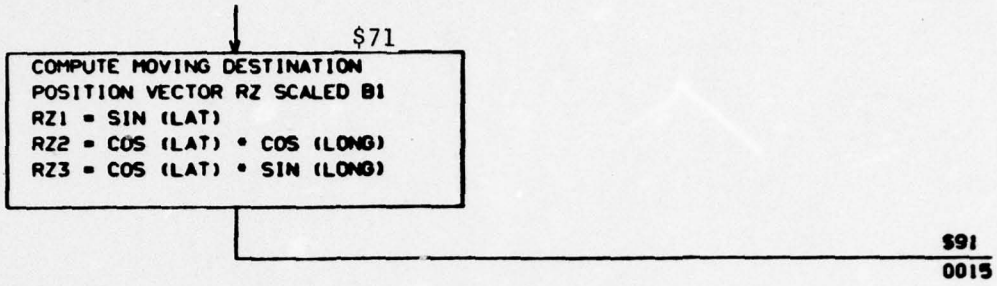




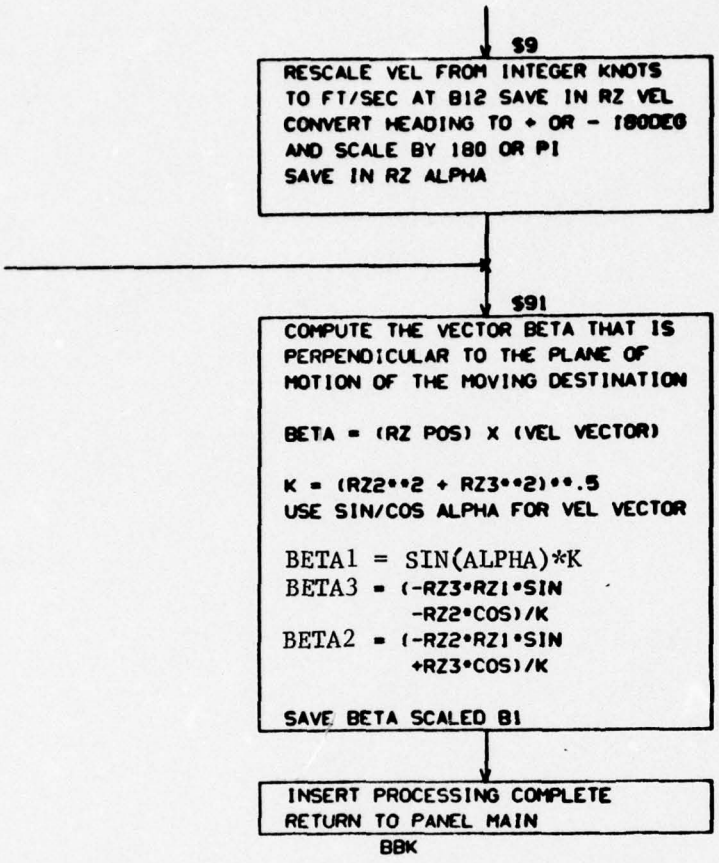
• POSITION UPDATE


$73
READ POINTER TO R1 VECTOR
COMPUTE CRAFT PRESENT POSITION
BSV
MAKE LAT LONG
COMPUTE POSITION ERROR
ERROR NORTH = LAT(NEW) - LAT
ERROR EAST = COS (LAT)
* (LONG(NEW) - LONG)
COMPUTE RADIAL ERROR SQUARED
= (ERR N)**2 + (ERR E)**2
DOES THE RADIAL
ERROR EXCEED 72 N MILE?
NO
YES
ERROR TOO LARGE
PROCESS THIS INSERT LIKE A FIRST
POSITION INSERT
$16
0012
$74
SCALE ERRORS IN RADIANS AT B-3
SAVE FOR KALMAN
SET POSITION FIX MARKER TO
NOTIFY KALMAN
SAVE ASSOCIATED VARIANCE
BBK

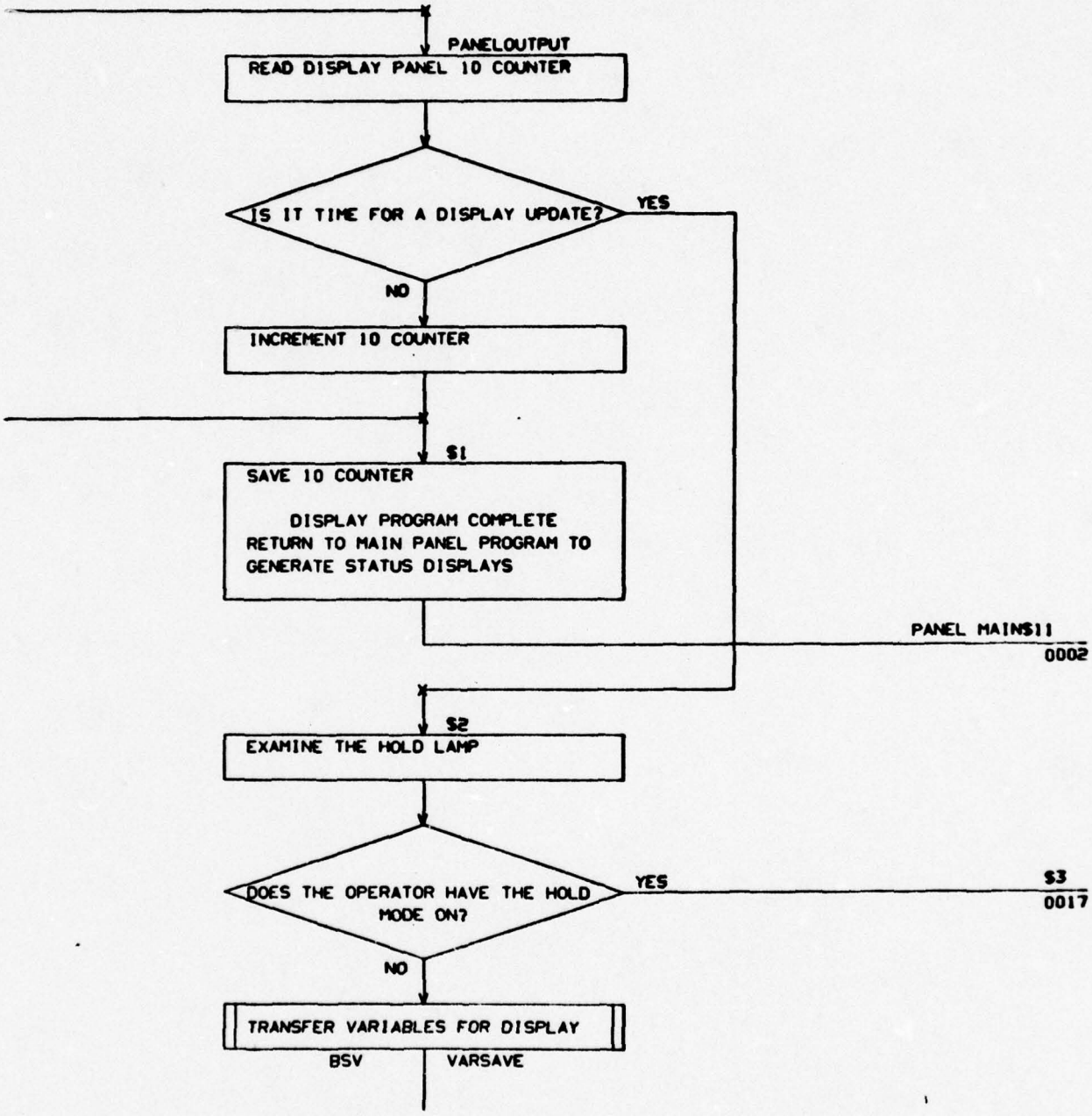
• ENTER HERE FOR A MOVING DESTINATION
• POSITION INSERT

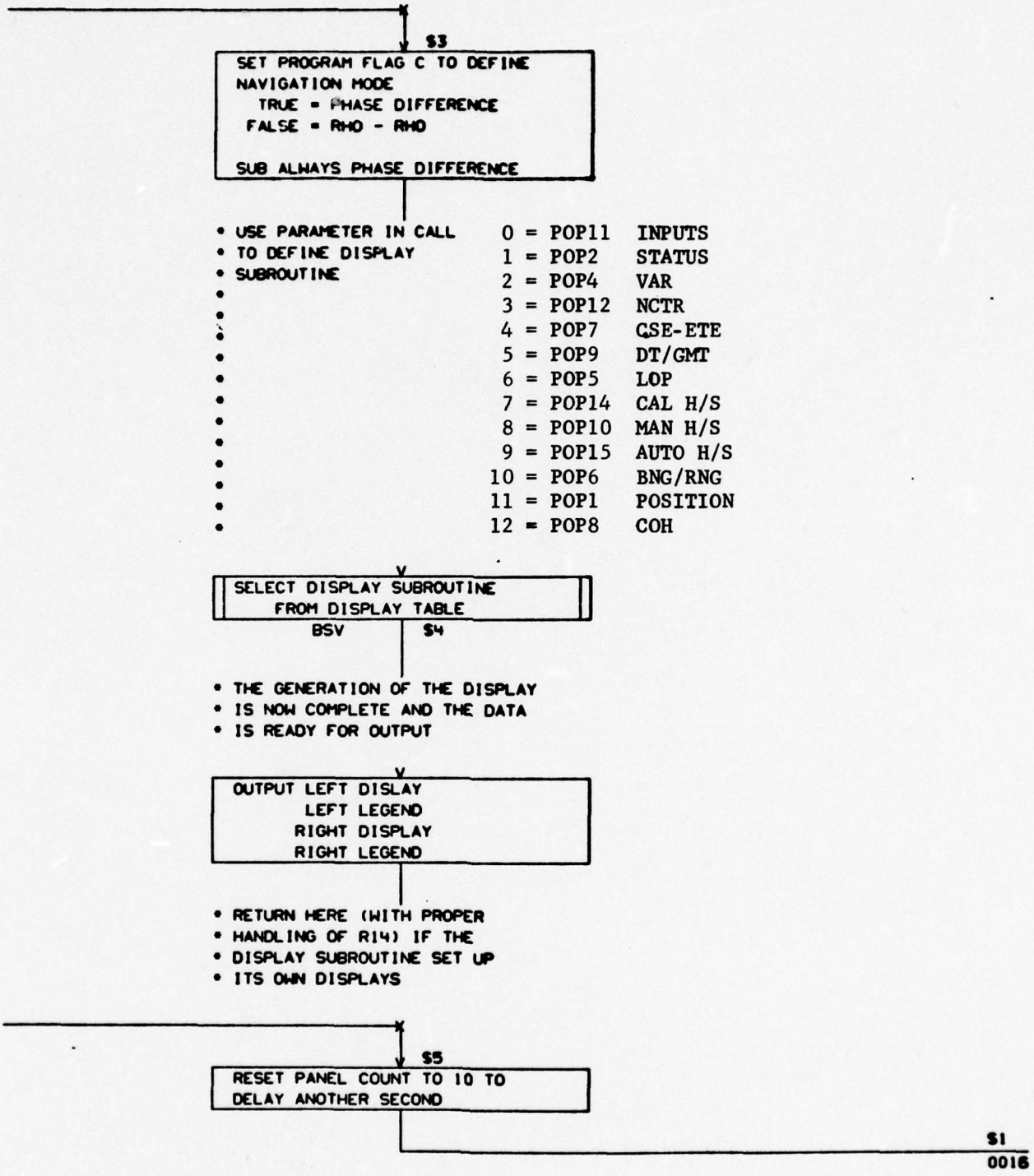


- ENTER HERE FOR A MOVING DESTINATION
- VELOCITY - HEADING INSERT

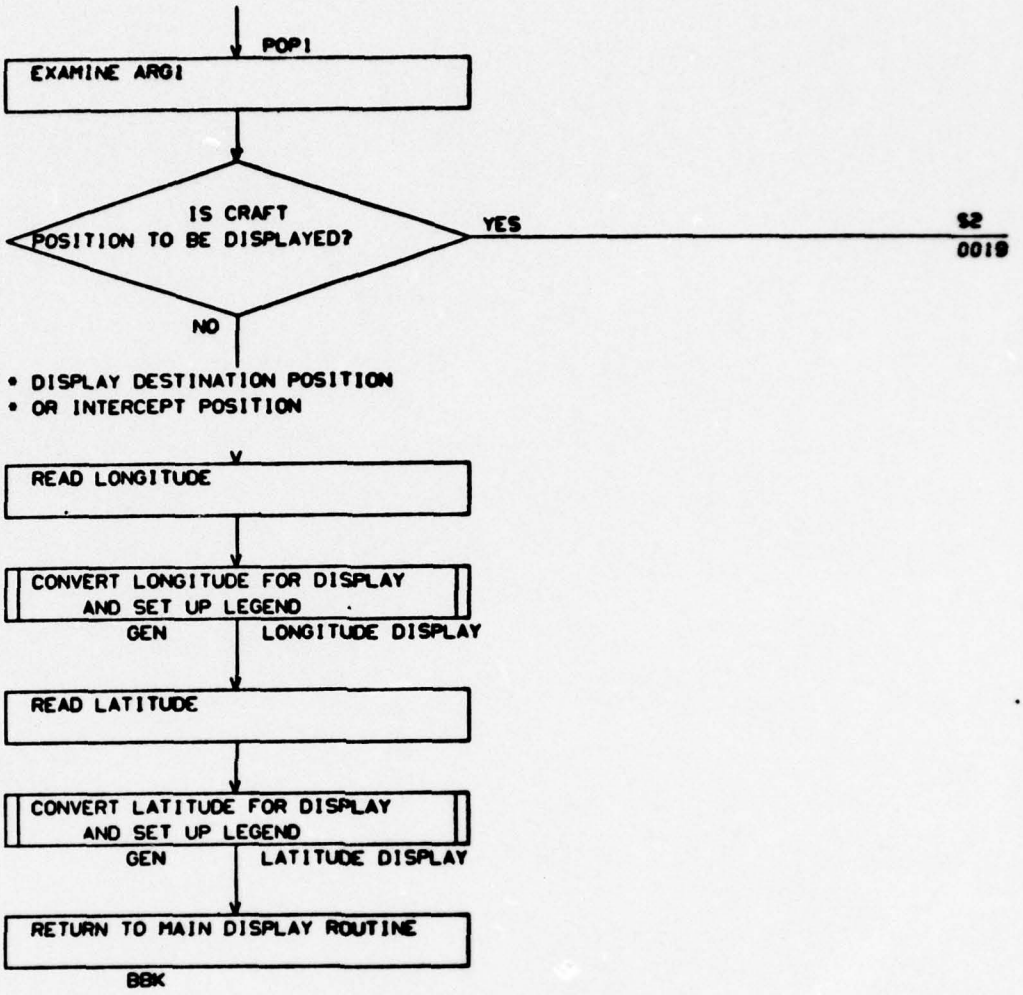


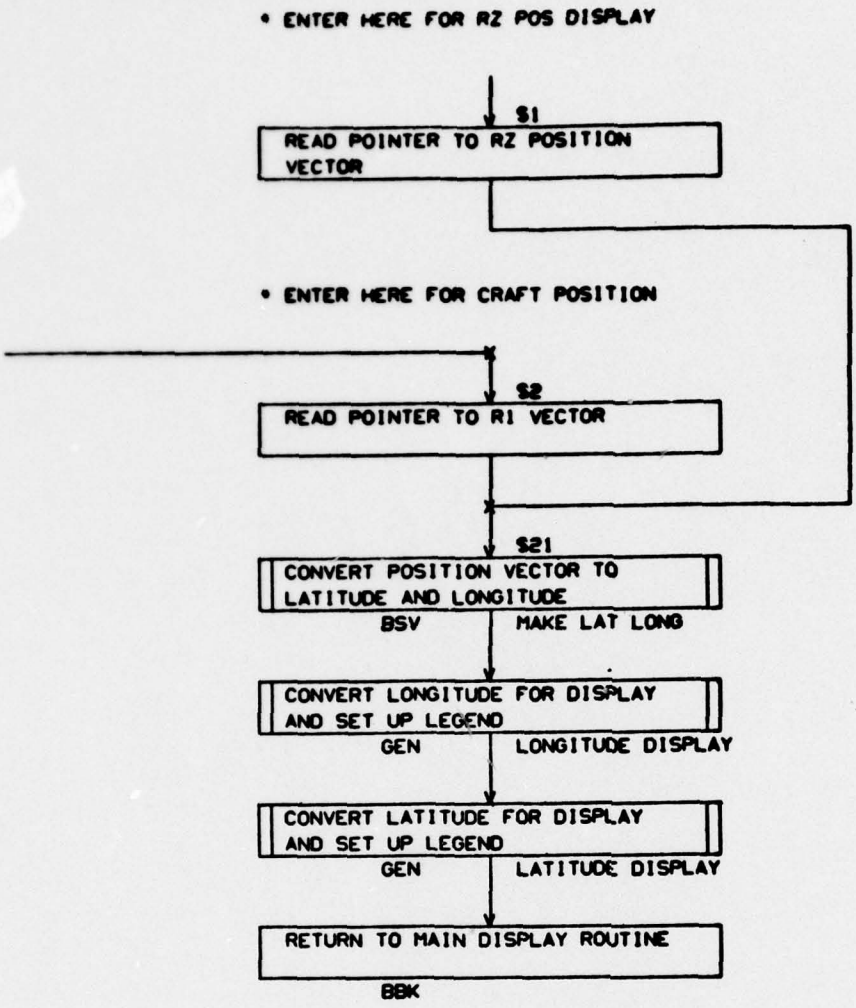
```
•                    DISPLAY PROGRAM
•
• THIS ROUTINE IS ENTERED FROM THE MAIN PANEL PROGRAM 10 TIMES A SECOND
• WHENEVER THE PANEL IS IN THE DISPLAY MODE (1).  IT GENERATES A NEW
• DISPLAY EVERY SECOND BASED ON THE PROCEDURE IDENTIFIED IN CALL.
•
```

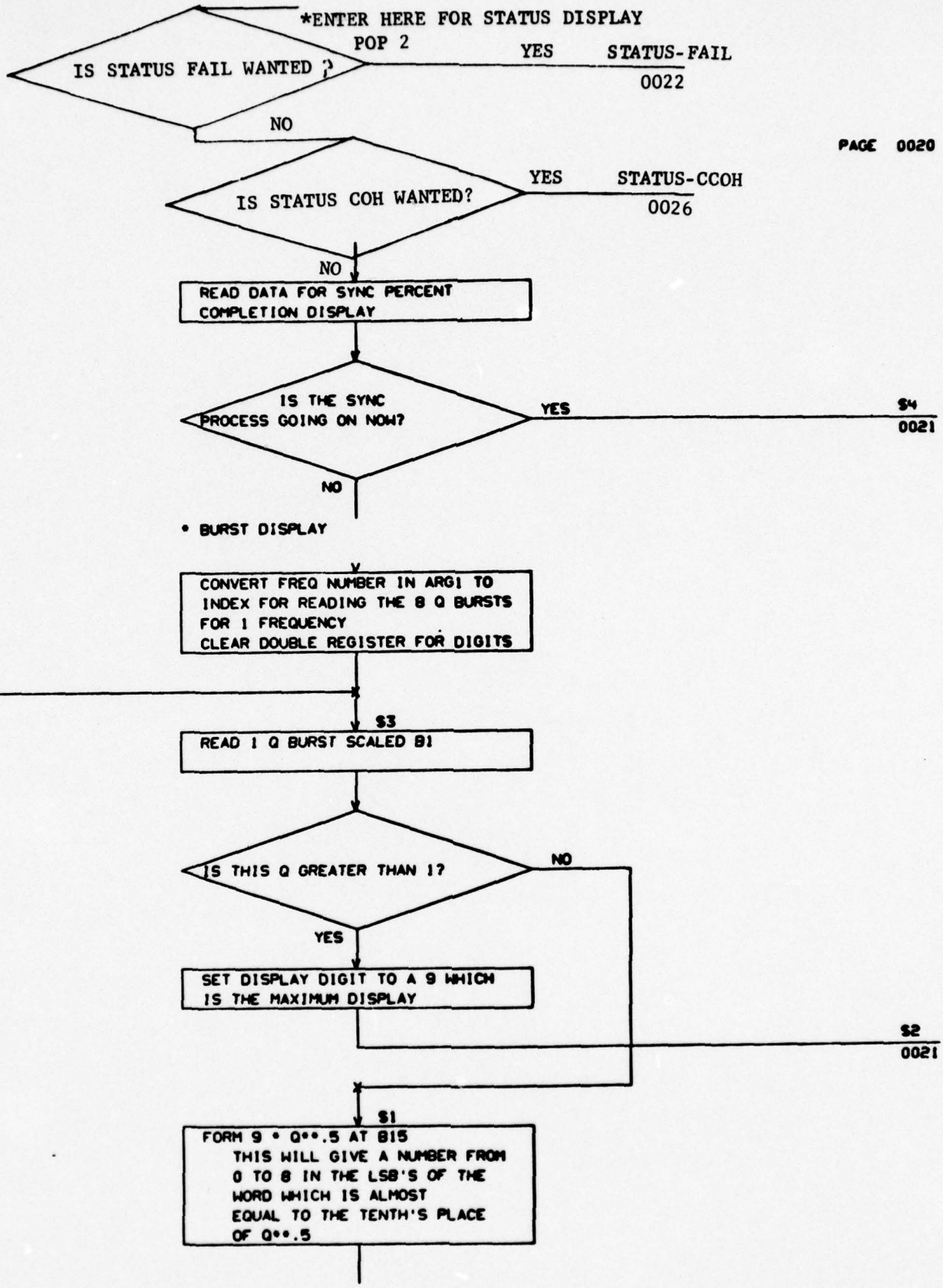


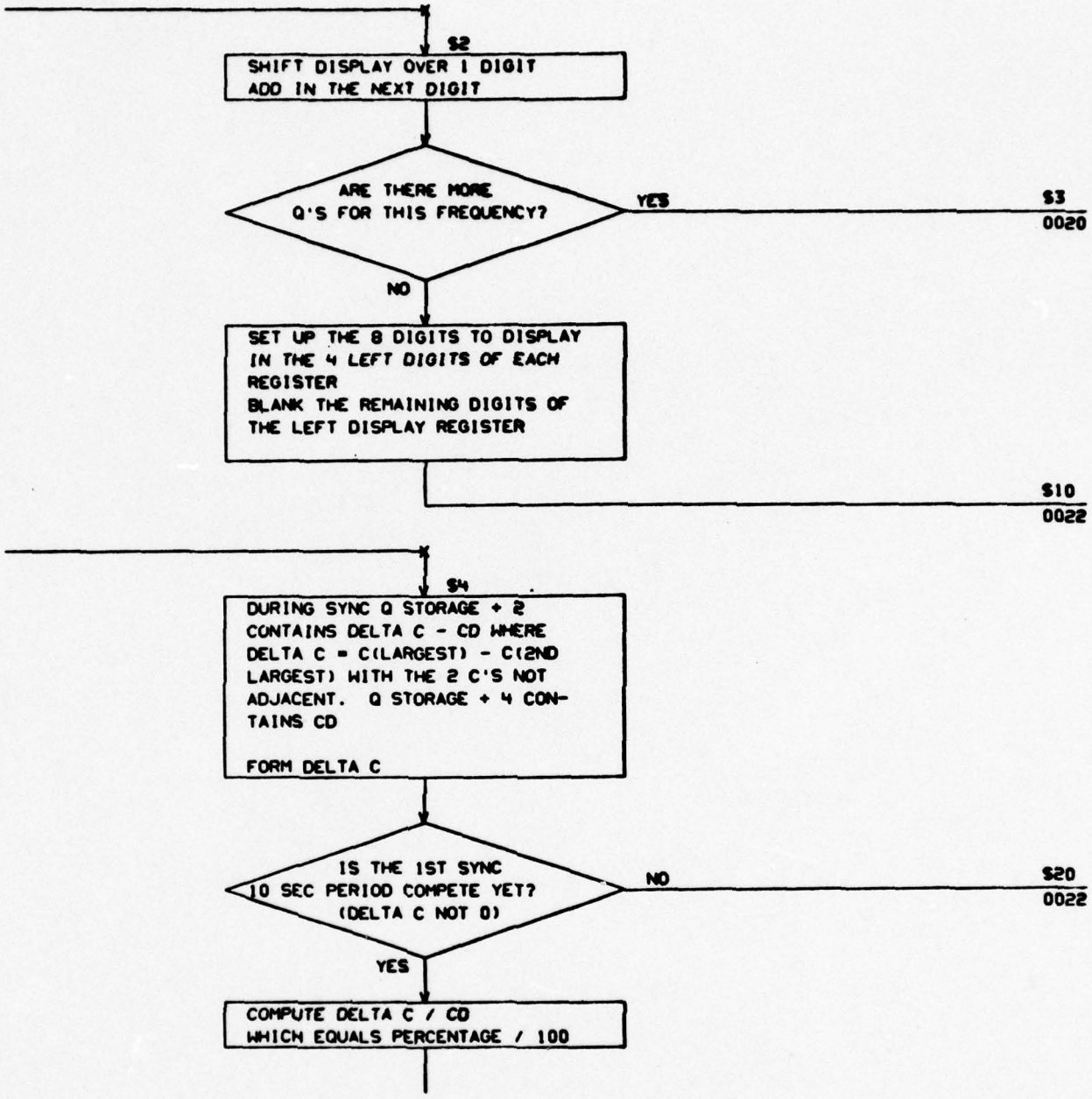

$3
SET PROGRAM FLAG C TO DEFINE
NAVIGATION MODE
TRUE = PHASE DIFFERENCE
FALSE = RHO - RHO
SUB ALWAYS PHASE DIFFERENCE
• USE PARAMETER IN CALL
• TO DEFINE DISPLAY
• SUBROUTINE
0 = POP11 INPUTS
1 = POP2 STATUS
2 = POP4 VAR
3 = POP12 NCTR
4 = POP7 GSE-ETE
5 = POP9 DT/GMT
6 = POP5 LOP
7 = POP14 CAL H/S
8 = POP10 MAN H/S
9 = POP15 AUTO H/S
10 = POP6 BNG/RNG
11 = POP1 POSITION
12 = POP8 COH
SELECT DISPLAY SUBROUTINE
FROM DISPLAY TABLE
BSV
$4
• THE GENERATION OF THE DISPLAY
• IS NOW COMPLETE AND THE DATA
• IS READY FOR OUTPUT
OUTPUT LEFT DISLAY
LEFT LEGEND
RIGHT DISPLAY
RIGHT LEGEND
• RETURN HERE (WITH PROPER
• HANDLING OF R14) IF THE
• DISPLAY SUBROUTINE SET UP
• ITS OWN DISPLAYS
$5
RESET PANEL COUNT TO 10 TO
DELAY ANOTHER SECOND
$1
0016

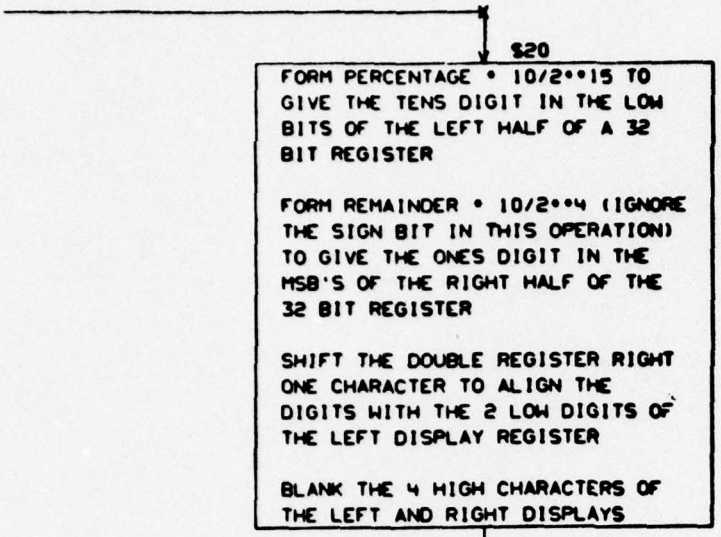
• ENTER HERE FOR POSITION DISPLAY

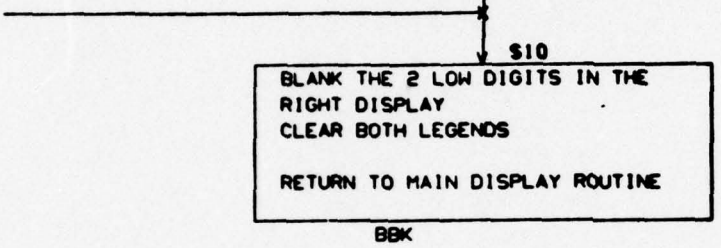


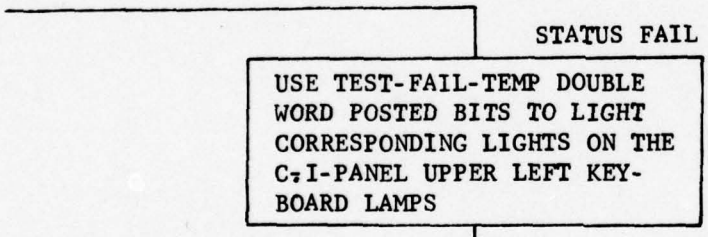

• ENTER HERE FOR RZ POS DISPLAY
S1
READ POINTER TO RZ POSITION VECTOR
• ENTER HERE FOR CRAFT POSITION
S2
READ POINTER TO R1 VECTOR
S21
CONVERT POSITION VECTOR TO LATITUDE AND LONGITUDE
BSV
MAKE LAT LONG
CONVERT LONGITUDE FOR DISPLAY AND SET UP LEGEND
GEN
LONGITUDE DISPLAY
CONVERT LATITUDE FOR DISPLAY AND SET UP LEGEND
GEN
LATITUDE DISPLAY
RETURN TO MAIN DISPLAY ROUTINE
BBK


*ENTER HERE FOR STATUS DISPLAY
POP 2
IS STATUS FAIL WANTED ?
YES
STATUS-FAIL
0022
NO
PAGE 0020
IS STATUS COH WANTED?
YES
STATUS-CCOH
0026
NO
READ DATA FOR SYNC PERCENT COMPLETION DISPLAY
IS THE SYNC PROCESS GOING ON NOW?
YES
$4
0021
NO
• BURST DISPLAY
CONVERT FREQ NUMBER IN ARG1 TO INDEX FOR READING THE 8 Q BURSTS FOR 1 FREQUENCY
CLEAR DOUBLE REGISTER FOR DIGITS
$3
READ 1 Q BURST SCALED B1
IS THIS Q GREATER THAN 1?
NO
YES
SET DISPLAY DIGIT TO A 9 WHICH IS THE MAXIMUM DISPLAY
$2
0021
$1
FORM 9 • Q**.5 AT B15
THIS WILL GIVE A NUMBER FROM 0 TO 8 IN THE LSB'S OF THE WORD WHICH IS ALMOST EQUAL TO THE TENTH'S PLACE OF Q**.5


$2
SHIFT DISPLAY OVER 1 DIGIT
ADD IN THE NEXT DIGIT
ARE THERE MORE
Q'S FOR THIS FREQUENCY?
YES
$3
0020
NO
SET UP THE 8 DIGITS TO DISPLAY
IN THE 4 LEFT DIGITS OF EACH
REGISTER
BLANK THE REMAINING DIGITS OF
THE LEFT DISPLAY REGISTER
$10
0022
$4
DURING SYNC Q STORAGE + 2
CONTAINS DELTA C - CD WHERE
DELTA C = C(LARGEST) - C(2ND
LARGEST) WITH THE 2 C'S NOT
ADJACENT. Q STORAGE + 4 CON-
TAINS CD
FORM DELTA C
IS THE 1ST SYNC
10 SEC PERIOD COMPETE YET?
(DELTA C NOT 0)
NO
$20
0022
YES
COMPUTE DELTA C / CD
WHICH EQUALS PERCENTAGE / 100



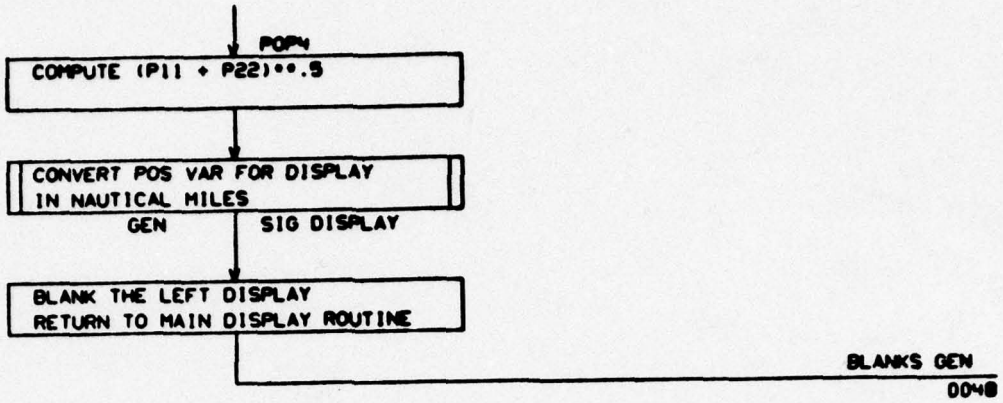




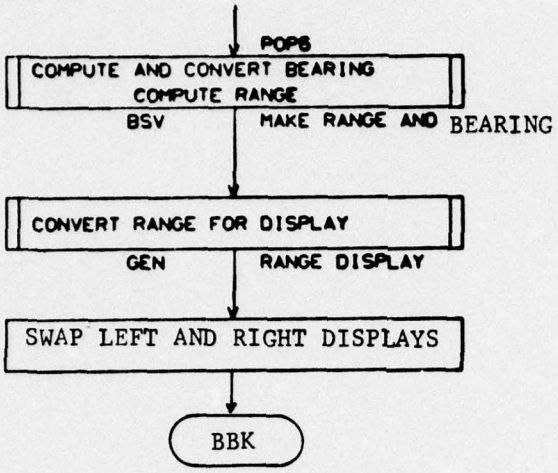
(See Volume XI for Discussions of Test Failures)

BLANKS - GEN
0048

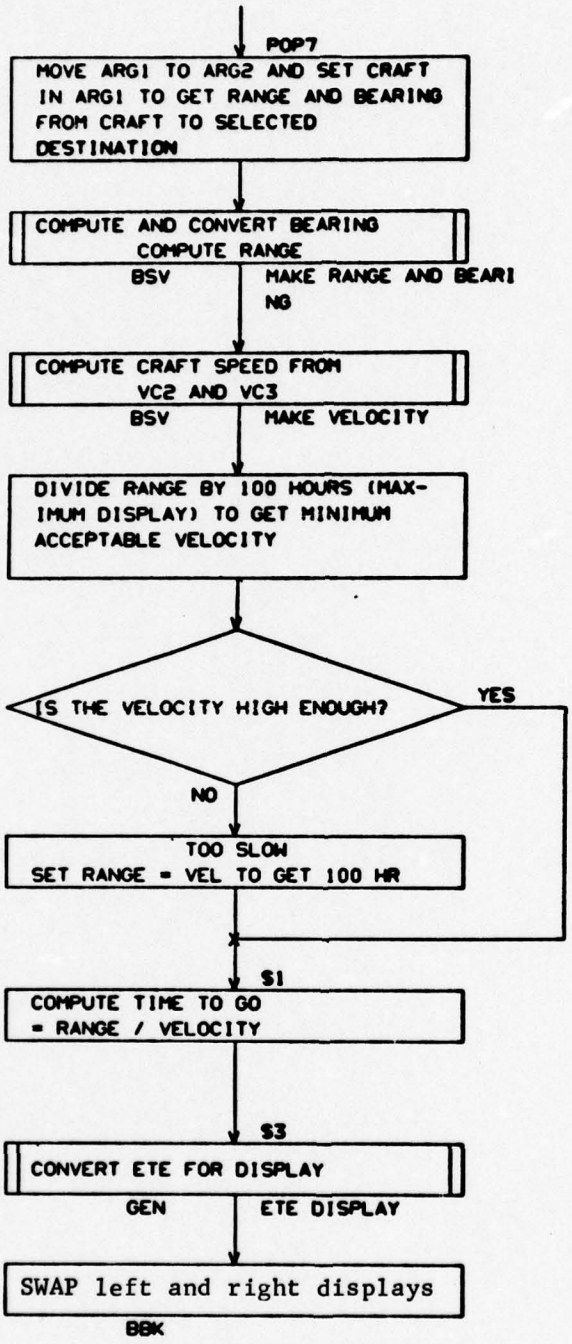
• ENTER HERE FOR POS VAR

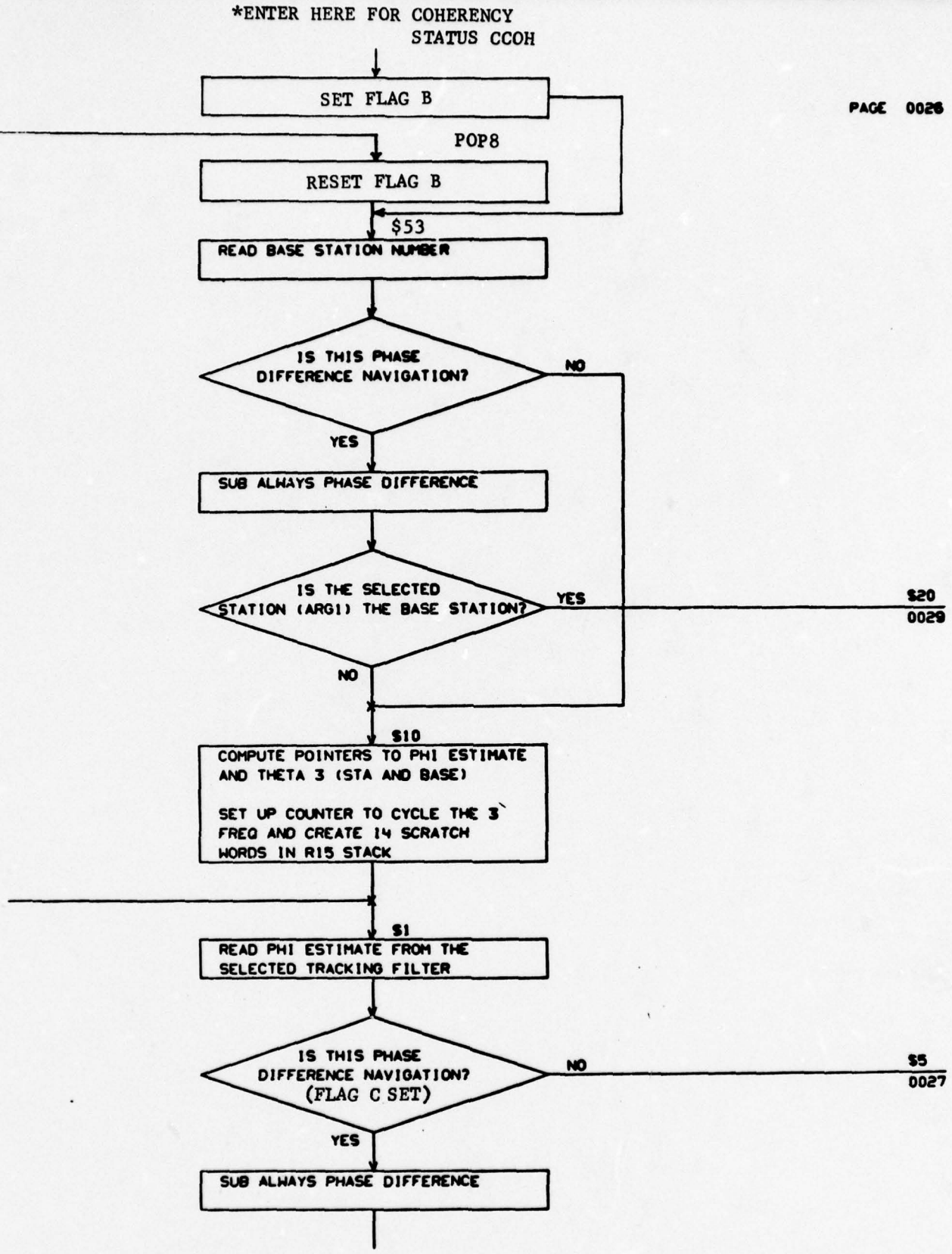


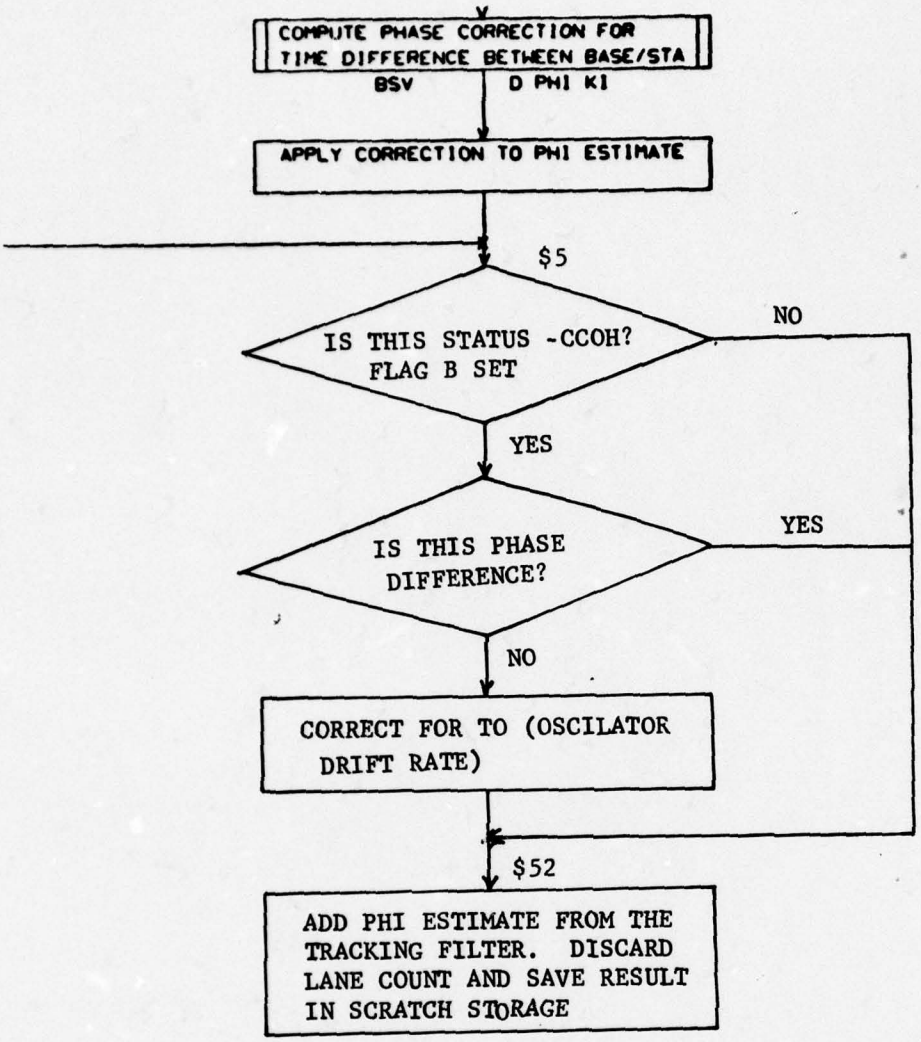
- ENTER HERE FOR RANGE AND BEARING
- RANGE START POINT IS IN ARG1
- RANGE END POINT IS IN ARG2

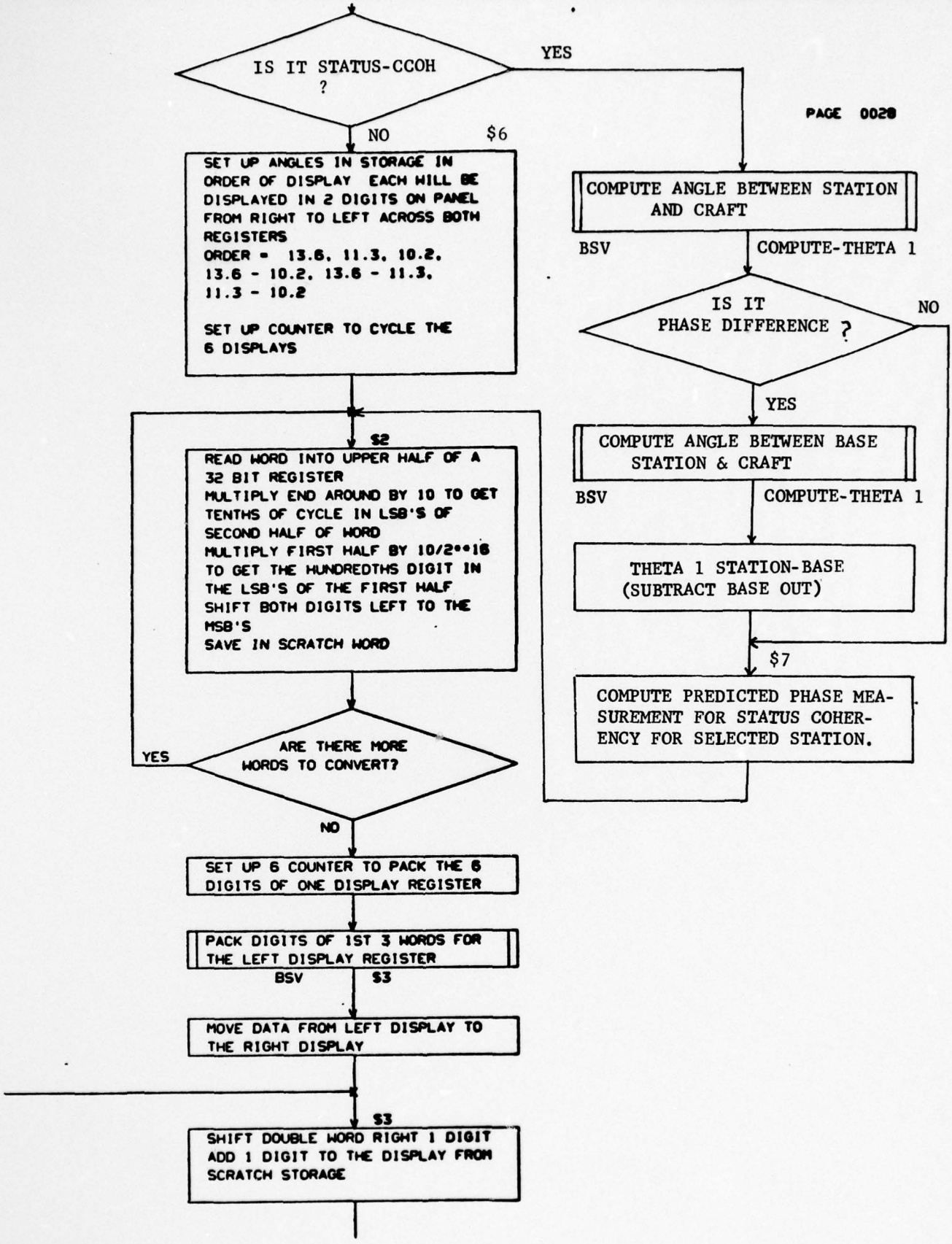


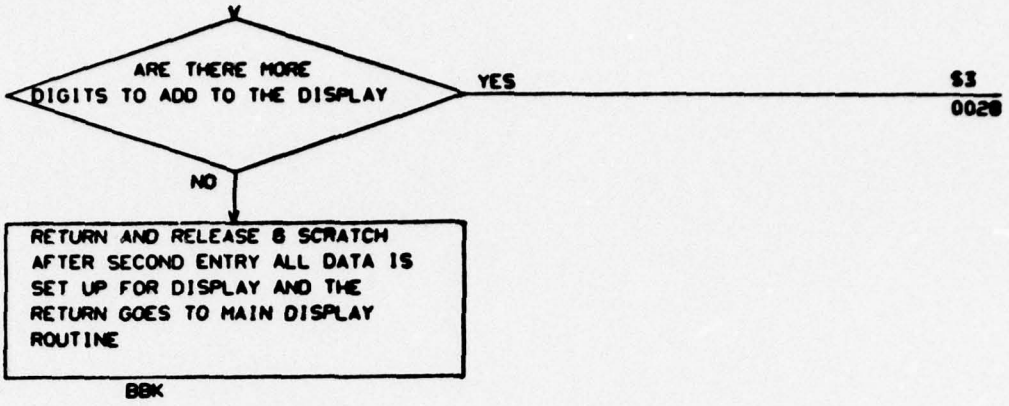
• ENTER HERE FOR ETE - CSE



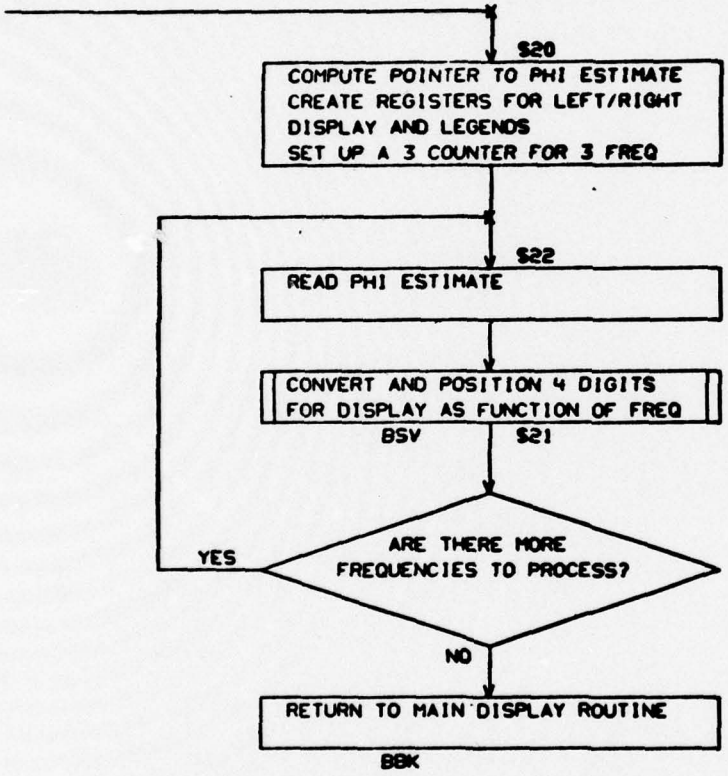

*ENTER HERE FOR COHERENCY
STATUS CCOH
SET FLAG B
PAGE 0026
POP8
RESET FLAG B
$53
READ BASE STATION NUMBER
IS THIS PHASE DIFFERENCE NAVIGATION?
NO
YES
SUB ALWAYS PHASE DIFFERENCE
IS THE SELECTED STATION (ARG1) THE BASE STATION?
YES
$20
0029
NO
$10
COMPUTE POINTERS TO PHI ESTIMATE AND THETA 3 (STA AND BASE)
SET UP COUNTER TO CYCLE THE 3 FREQ AND CREATE 14 SCRATCH WORDS IN R15 STACK
$1
READ PHI ESTIMATE FROM THE SELECTED TRACKING FILTER
IS THIS PHASE DIFFERENCE NAVIGATION? (FLAG C SET)
NO
$5
0027
YES
SUB ALWAYS PHASE DIFFERENCE


COMPUTE PHASE CORRECTION FOR TIME DIFFERENCE BETWEEN BASE/STA
BSV
D PHI K1
APPLY CORRECTION TO PHI ESTIMATE
$5
IS THIS STATUS -CCOH? FLAG B SET
NO
YES
IS THIS PHASE DIFFERENCE?
YES
NO
CORRECT FOR TO (OSCILATOR DRIFT RATE)
$52
ADD PHI ESTIMATE FROM THE TRACKING FILTER. DISCARD LANE COUNT AND SAVE RESULT IN SCRATCH STORAGE

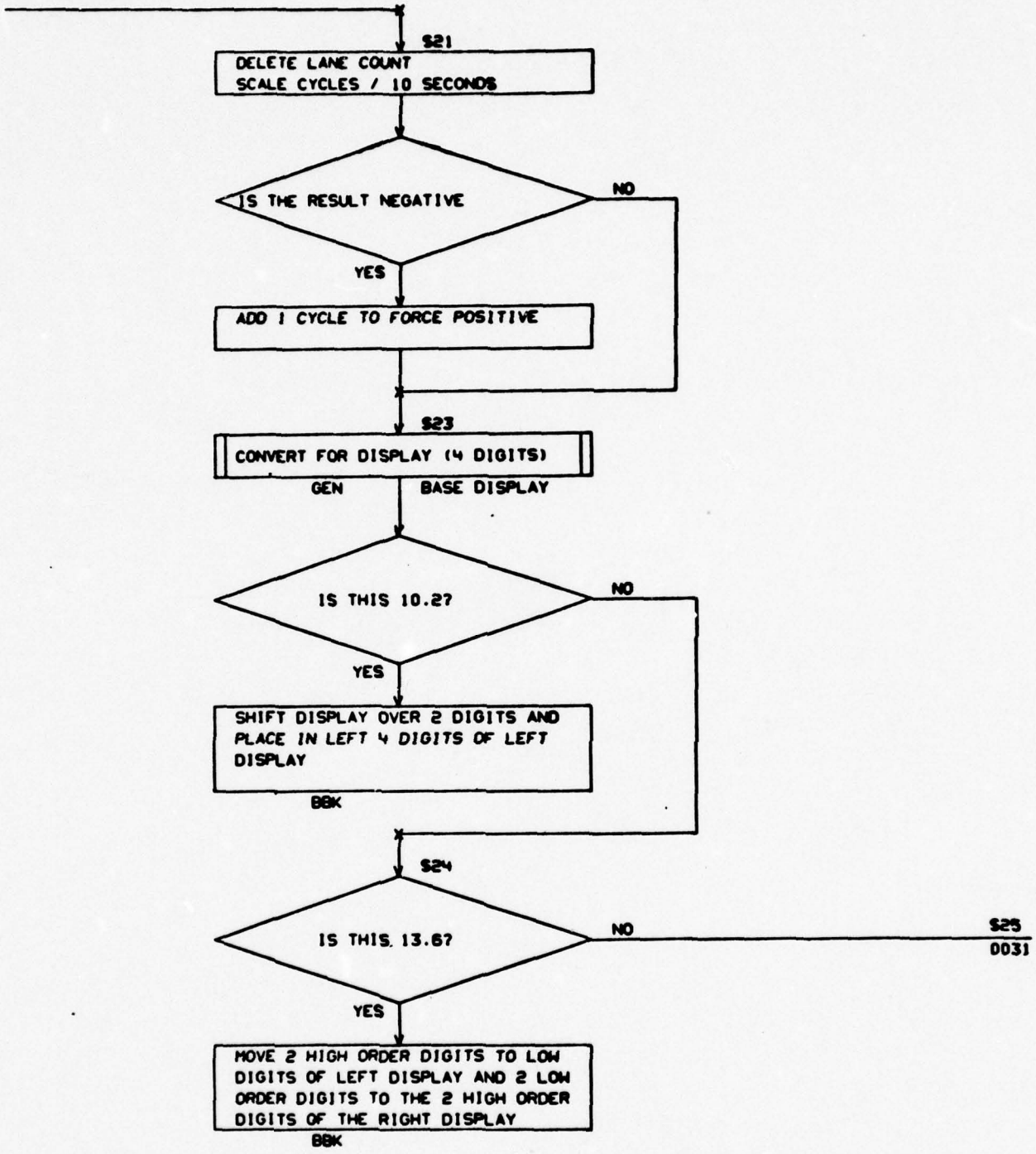

IS IT STATUS-CCOH ?
YES
NO
$6
PAGE 0028
SET UP ANGLES IN STORAGE IN ORDER OF DISPLAY EACH WILL BE DISPLAYED IN 2 DIGITS ON PANEL FROM RIGHT TO LEFT ACROSS BOTH REGISTERS
ORDER = 13.6, 11.3, 10.2, 13.6 - 10.2, 13.6 - 11.3, 11.3 - 10.2
SET UP COUNTER TO CYCLE THE 6 DISPLAYS
COMPUTE ANGLE BETWEEN STATION AND CRAFT
BSV
COMPUTE-THETA 1
IS IT PHASE DIFFERENCE ?
NO
YES
COMPUTE ANGLE BETWEEN BASE STATION & CRAFT
BSV
COMPUTE-THETA 1
THETA 1 STATION-BASE (SUBTRACT BASE OUT)
$7
COMPUTE PREDICTED PHASE MEASUREMENT FOR STATUS COHERENCY FOR SELECTED STATION.
$2
READ WORD INTO UPPER HALF OF A 32 BIT REGISTER
MULTIPLY END AROUND BY 10 TO GET TENTHS OF CYCLE IN LSB'S OF SECOND HALF OF WORD
MULTIPLY FIRST HALF BY 10/2**16 TO GET THE HUNDREDTHS DIGIT IN THE LSB'S OF THE FIRST HALF
SHIFT BOTH DIGITS LEFT TO THE MSB'S
SAVE IN SCRATCH WORD
ARE THERE MORE WORDS TO CONVERT?
YES
NO
SET UP 6 COUNTER TO PACK THE 6 DIGITS OF ONE DISPLAY REGISTER
PACK DIGITS OF 1ST 3 WORDS FOR THE LEFT DISPLAY REGISTER
BSV
$3
MOVE DATA FROM LEFT DISPLAY TO THE RIGHT DISPLAY
$3
SHIFT DOUBLE WORD RIGHT 1 DIGIT
ADD 1 DIGIT TO THE DISPLAY FROM SCRATCH STORAGE

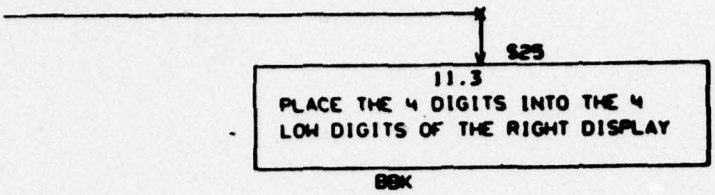


• BASE STATION TRACKING FILTER DISPLAY

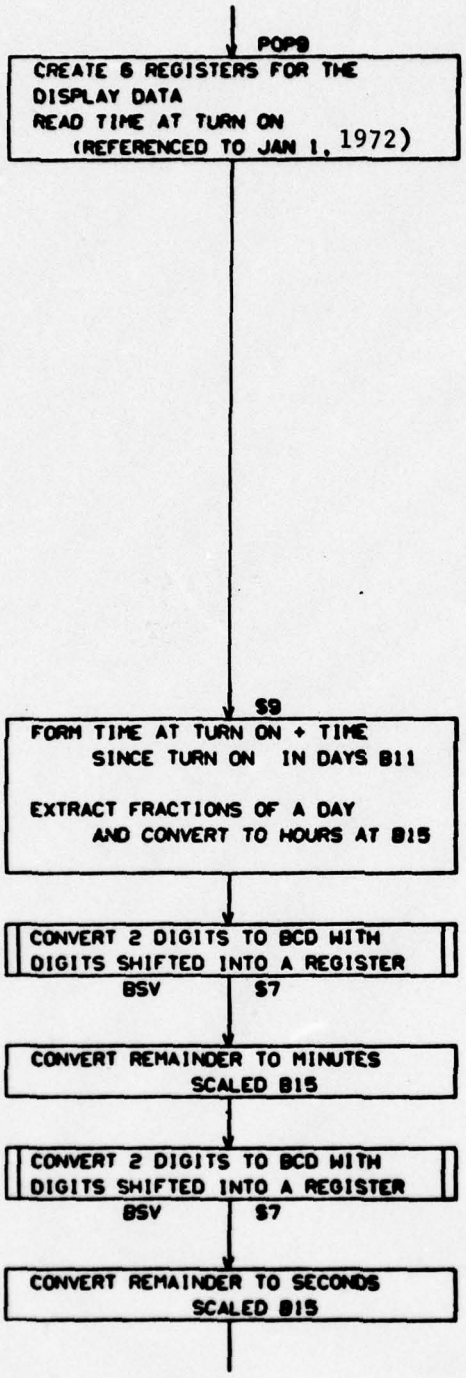


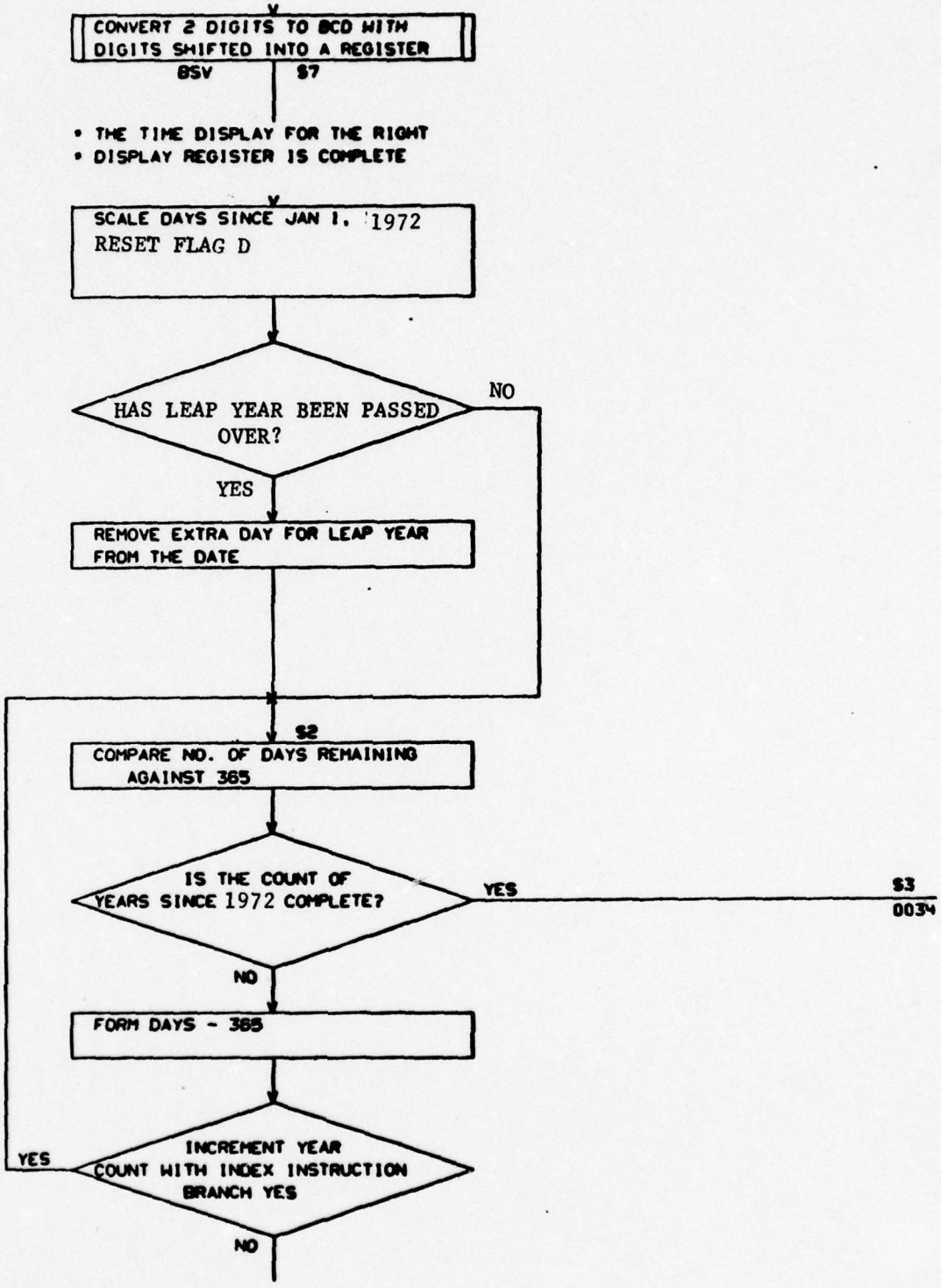
• SCALE PHI IN CYCLES/10 SEC AND
• DISPLAY 4 DIGITS TO RIGHT OF
• DECIMAL. THE 12 DIGITS ON THE
• DISPLAY WILL READ 10.2, 13.8
• AND 11.3 FROM LEFT TO RIGHT

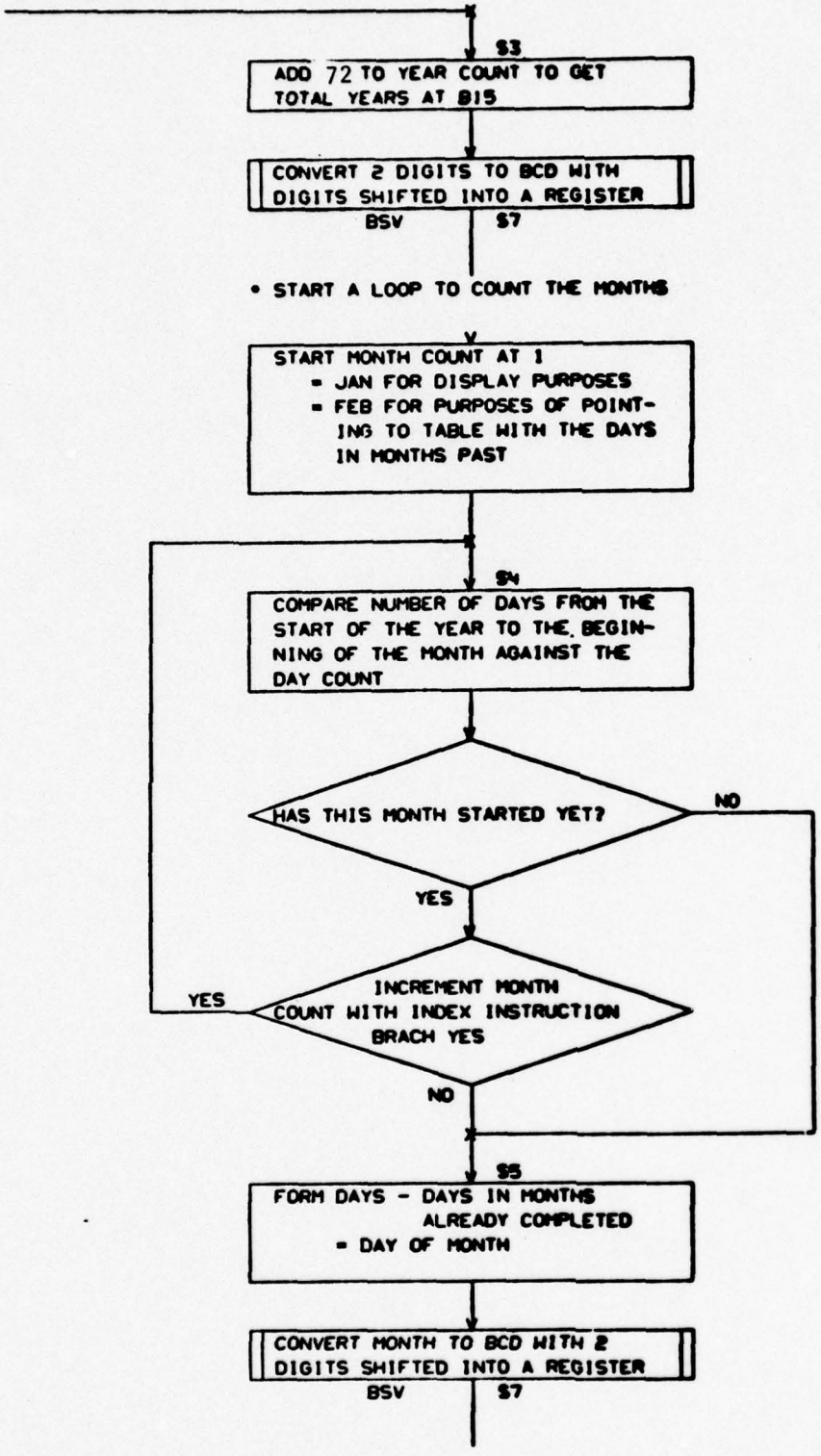

S21
DELETE LANE COUNT
SCALE CYCLES / 10 SECONDS
IS THE RESULT NEGATIVE
NO
YES
ADD 1 CYCLE TO FORCE POSITIVE
S23
CONVERT FOR DISPLAY (4 DIGITS)
GEN
BASE DISPLAY
IS THIS 10.2?
NO
YES
SHIFT DISPLAY OVER 2 DIGITS AND PLACE IN LEFT 4 DIGITS OF LEFT DISPLAY
BBK
S24
IS THIS 13.6?
NO
S25
0031
YES
MOVE 2 HIGH ORDER DIGITS TO LOW DIGITS OF LEFT DISPLAY AND 2 LOW ORDER DIGITS TO THE 2 HIGH ORDER DIGITS OF THE RIGHT DISPLAY
BBK

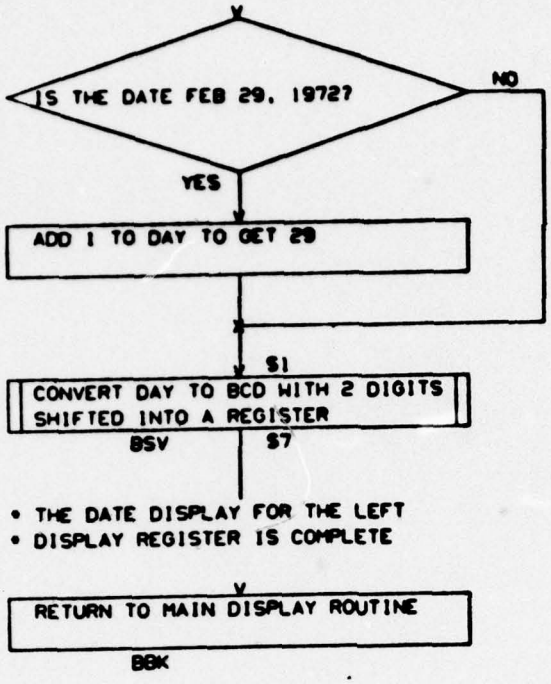

S25
11.3
PLACE THE 4 DIGITS INTO THE 4
LOW DIGITS OF THE RIGHT DISPLAY
BBK

• ENTER HERE FOR D-GMT DISPLAY

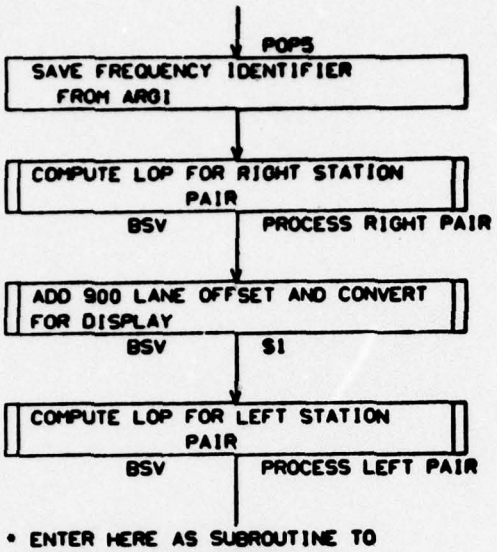



CONVERT 2 DIGITS TO BCD WITH DIGITS SHIFTED INTO A REGISTER
BSV
$7
• THE TIME DISPLAY FOR THE RIGHT
• DISPLAY REGISTER IS COMPLETE
SCALE DAYS SINCE JAN 1, 1972
RESET FLAG D
HAS LEAP YEAR BEEN PASSED OVER?
NO
YES
REMOVE EXTRA DAY FOR LEAP YEAR FROM THE DATE
$2
COMPARE NO. OF DAYS REMAINING AGAINST 365
IS THE COUNT OF YEARS SINCE 1972 COMPLETE?
YES
$3
0034
NO
FORM DAYS - 365
INCREMENT YEAR COUNT WITH INDEX INSTRUCTION BRANCH YES
YES
NO

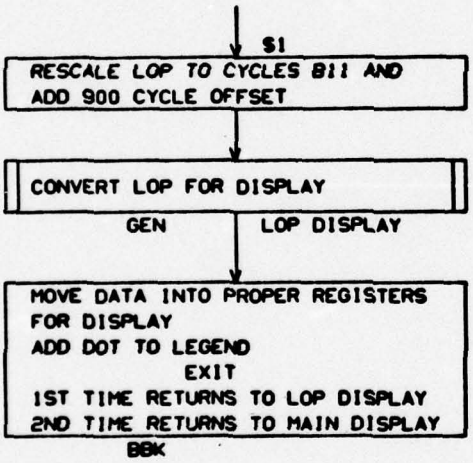

$3
ADD 72 TO YEAR COUNT TO GET TOTAL YEARS AT B15
CONVERT 2 DIGITS TO BCD WITH DIGITS SHIFTED INTO A REGISTER
BSV
$7
• START A LOOP TO COUNT THE MONTHS
START MONTH COUNT AT 1
= JAN FOR DISPLAY PURPOSES
= FEB FOR PURPOSES OF POINTING TO TABLE WITH THE DAYS IN MONTHS PAST
$4
COMPARE NUMBER OF DAYS FROM THE START OF THE YEAR TO THE BEGINNING OF THE MONTH AGAINST THE DAY COUNT
HAS THIS MONTH STARTED YET?
NO
YES
INCREMENT MONTH COUNT WITH INDEX INSTRUCTION BRACH YES
YES
NO
$5
FORM DAYS - DAYS IN MONTHS ALREADY COMPLETED
= DAY OF MONTH
CONVERT MONTH TO BCD WITH 2 DIGITS SHIFTED INTO A REGISTER
BSV
$7


IS THE DATE FEB 29, 1972?
NO
YES
ADD 1 TO DAY TO GET 29
$1
CONVERT DAY TO BCD WITH 2 DIGITS SHIFTED INTO A REGISTER
BSV
$7
• THE DATE DISPLAY FOR THE LEFT
• DISPLAY REGISTER IS COMPLETE
RETURN TO MAIN DISPLAY ROUTINE
BBK

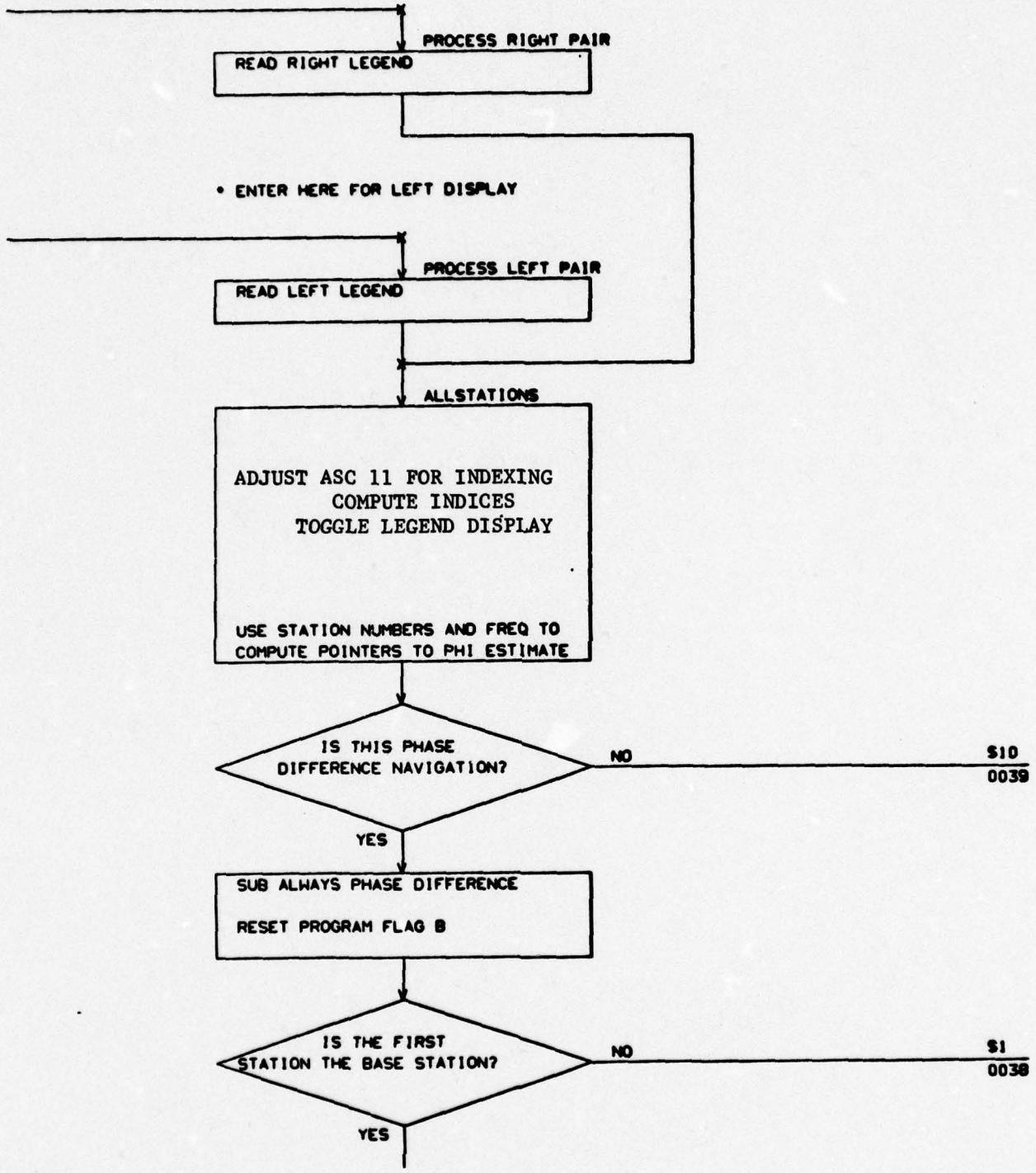
```
• ENTER HERE FOR LOP
```

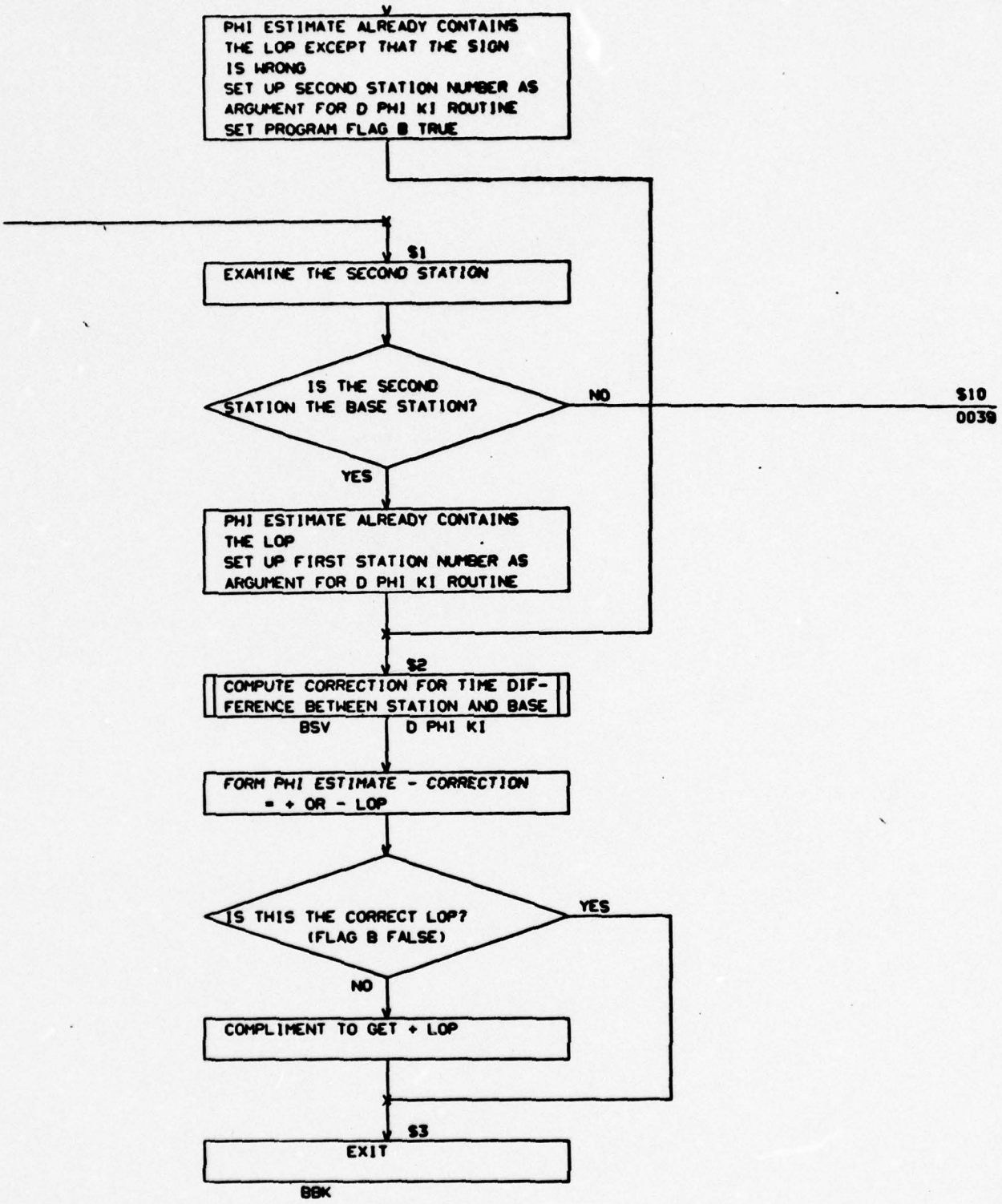


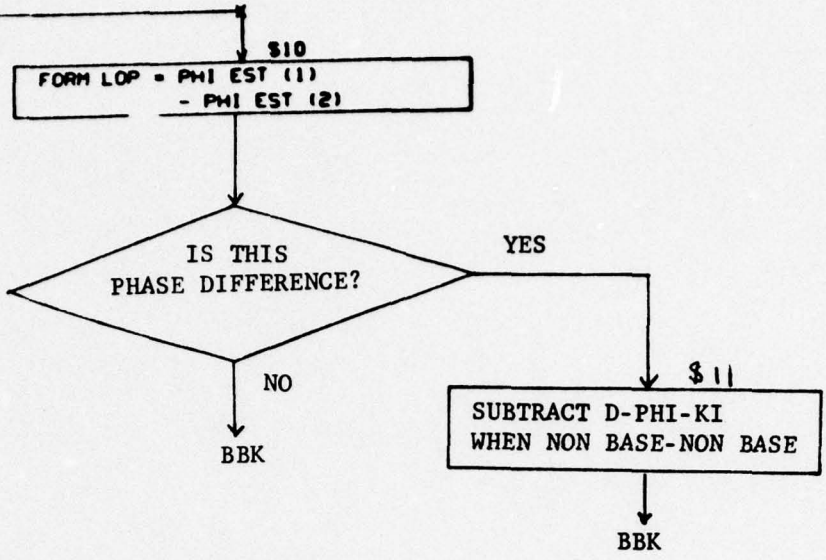

```
• ENTER HERE AS SUBROUTINE TO
• CONVERT RIGHT DISPLAY.
• FALL INTO ROUTINE TO CONVERT
• LEFT DISPLAY AND EXIT
```



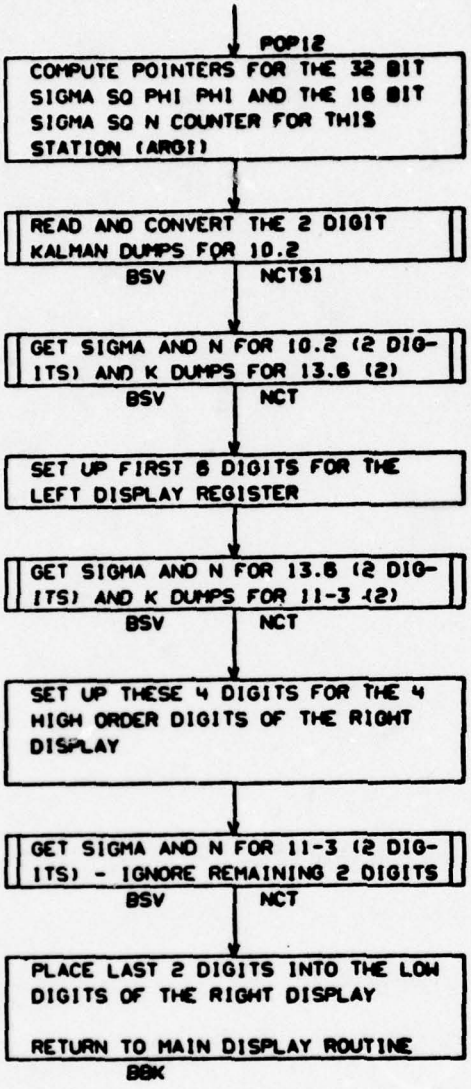

```
•                          COMPUTE LOP
•
• THIS ROUTINE WILL COMPUTE THE LOP FOR THE STATION PAIR DISPLAYED IN
• THE LEFT OR RIGHT LEGEND
•
• ENTER HERE FOR RIGHT DISPLAY
```


PROCESS RIGHT PAIR
READ RIGHT LEGEND
• ENTER HERE FOR LEFT DISPLAY
PROCESS LEFT PAIR
READ LEFT LEGEND
ALLSTATIONS
ADJUST ASC 11 FOR INDEXING
COMPUTE INDICES
TOGGLE LEGEND DISPLAY
USE STATION NUMBERS AND FREQ TO
COMPUTE POINTERS TO PHI ESTIMATE
IS THIS PHASE
DIFFERENCE NAVIGATION?
NO
$10
0039
YES
SUB ALWAYS PHASE DIFFERENCE
RESET PROGRAM FLAG B
IS THE FIRST
STATION THE BASE STATION?
NO
$1
0038
YES

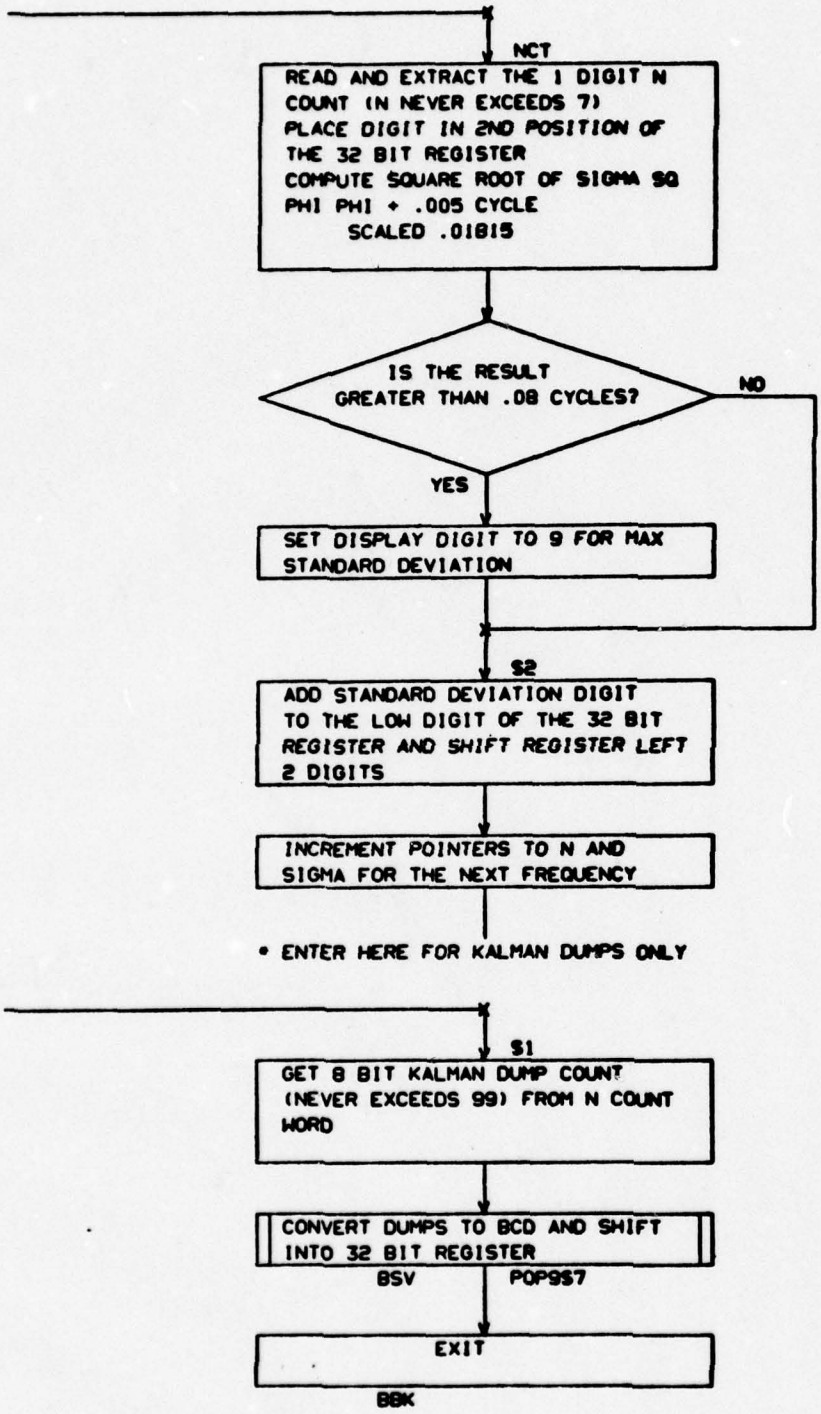

PHI ESTIMATE ALREADY CONTAINS THE LOP EXCEPT THAT THE SIGN IS WRONG
SET UP SECOND STATION NUMBER AS ARGUMENT FOR D PHI KI ROUTINE
SET PROGRAM FLAG B TRUE
$1
EXAMINE THE SECOND STATION
IS THE SECOND STATION THE BASE STATION?
NO
$10
0039
YES
PHI ESTIMATE ALREADY CONTAINS THE LOP
SET UP FIRST STATION NUMBER AS ARGUMENT FOR D PHI KI ROUTINE
$2
COMPUTE CORRECTION FOR TIME DIFFERENCE BETWEEN STATION AND BASE
BSV
D PHI KI
FORM PHI ESTIMATE - CORRECTION = + OR - LOP
IS THIS THE CORRECT LOP? (FLAG B FALSE)
YES
NO
COMPLIMENT TO GET + LOP
$3
EXIT
BBK

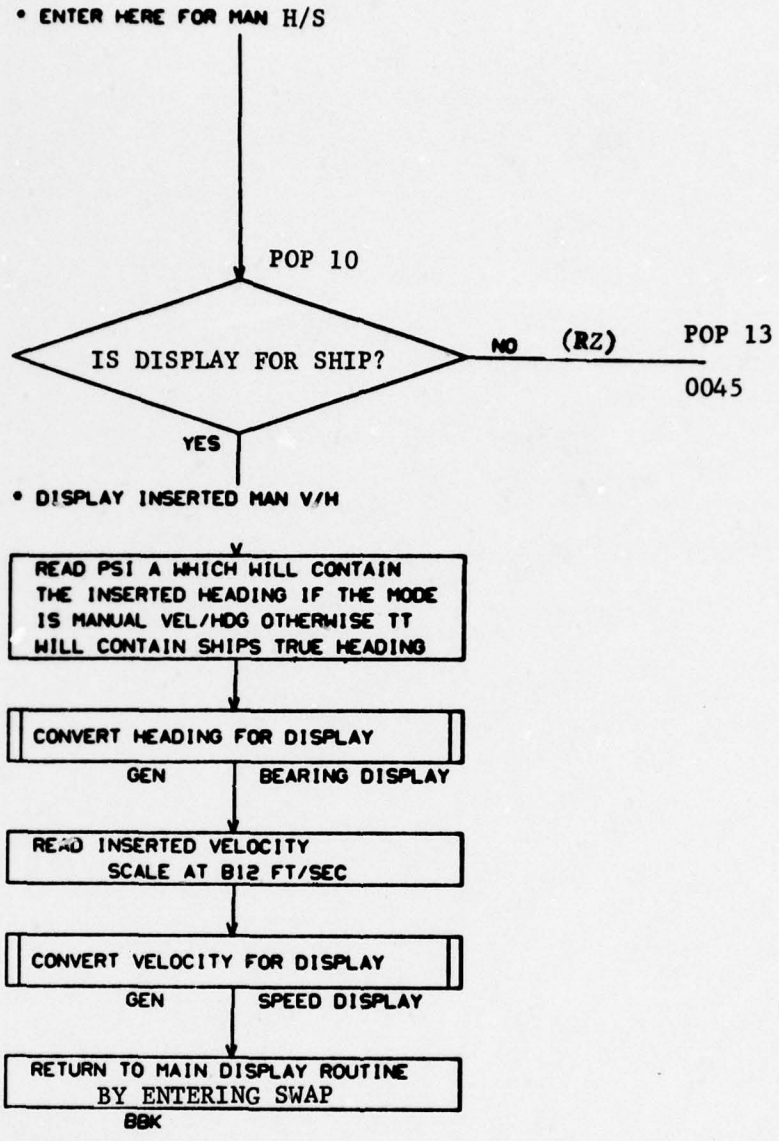

$10
FORM LOP = PHI EST (1)
- PHI EST (2)
IS THIS
PHASE DIFFERENCE?
YES
NO
BBK
$11
SUBTRACT D-PHI-KI
WHEN NON BASE-NON BASE
BBK

• ENTER HERE FOR NCTR DISPLAY



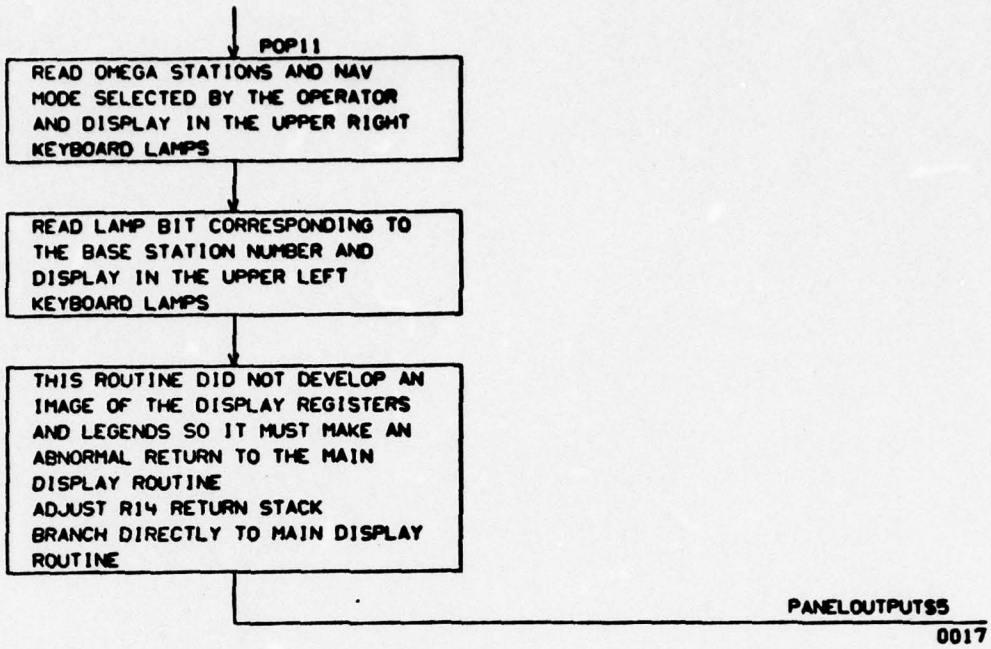

```
•                    CONVERT N, KALMAN DUMPS AND VARIANCE
•
• THIS ROUTINE IS USE BY THE NCTR DISPLAY ROUTINE TO GET THE N COUNTS,
• KALMAN DUMPS AND SOURE ROOT OF THE TRACKING FILTER VARIANCE.  THE
• ARGUMENTS CONSIST OF POINTERS TO N COUNT AND SIGMA.  THE OUTPUT DIGITS
• ARE LEFT IN THE 6 MOST SIGNIFICANT DIGITS OF A 32 BIT REGISTER.
•
```


NCT
READ AND EXTRACT THE 1 DIGIT N COUNT (N NEVER EXCEEDS 7) PLACE DIGIT IN 2ND POSITION OF THE 32 BIT REGISTER COMPUTE SQUARE ROOT OF SIGMA SQ PHI PHI + .005 CYCLE SCALED .01815
IS THE RESULT GREATER THAN .08 CYCLES?
NO
YES
SET DISPLAY DIGIT TO 9 FOR MAX STANDARD DEVIATION
S2
ADD STANDARD DEVIATION DIGIT TO THE LOW DIGIT OF THE 32 BIT REGISTER AND SHIFT REGISTER LEFT 2 DIGITS
INCREMENT POINTERS TO N AND SIGMA FOR THE NEXT FREQUENCY
• ENTER HERE FOR KALMAN DUMPS ONLY
S1
GET 8 BIT KALMAN DUMP COUNT (NEVER EXCEEDS 99) FROM N COUNT WORD
CONVERT DUMPS TO BCD AND SHIFT INTO 32 BIT REGISTER
BSV
POP9S7
EXIT
BBK

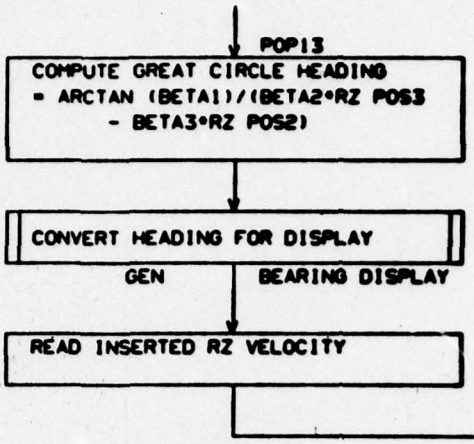

• ENTER HERE FOR MAN H/S
POP 10
IS DISPLAY FOR SHIP?
NO
(RZ)
POP 13
0045
YES
• DISPLAY INSERTED MAN V/H
READ PSI A WHICH WILL CONTAIN THE INSERTED HEADING IF THE MODE IS MANUAL VEL/HDG OTHERWISE TT WILL CONTAIN SHIPS TRUE HEADING
CONVERT HEADING FOR DISPLAY
GEN
BEARING DISPLAY
READ INSERTED VELOCITY SCALE AT B12 FT/SEC
CONVERT VELOCITY FOR DISPLAY
GEN
SPEED DISPLAY
RETURN TO MAIN DISPLAY ROUTINE BY ENTERING SWAP
BBK

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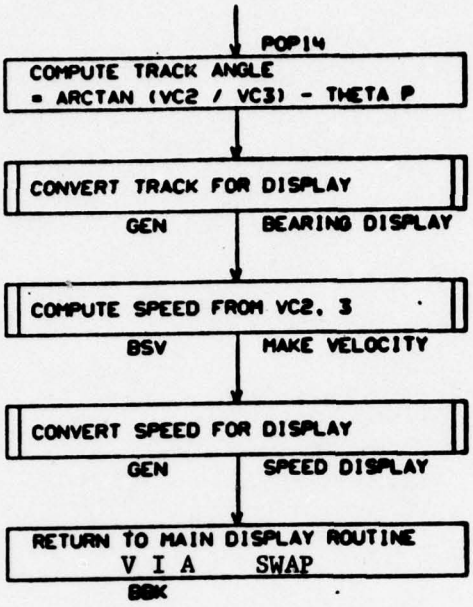
• ENTER HERE FOR INPUTS



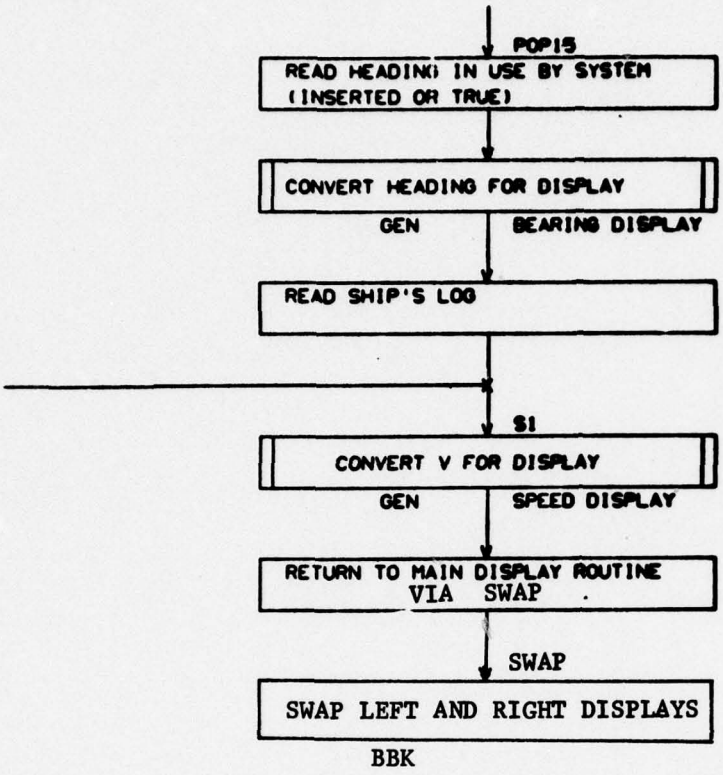
• ENTER HERE FOR MAN H/S RZ



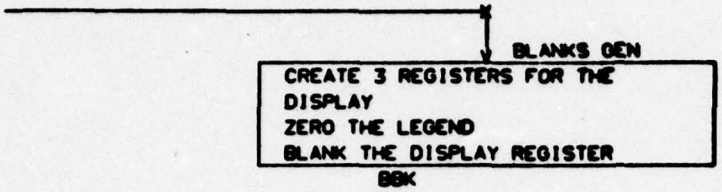
• ENTER HERE FOR CAL H/S



• ENTER HERE FOR AUTO H/S



```
•                    BLANKS
•
• THIS ROUTINE WILL BLANK ONE REGISTER AND LEGEND AND RETURN
•
```



3.2 CONTROL-INDICATOR INTERRUPT ROUTINE

The following routines may be found in this section:

ROUTINE	DIAGRAM PAGE	ROUTINE	DIAGRAM PAGE
PANEL INPUT	49	PANEL PIN SUBROUTINES	66
LOOP/FLOAT	50		
PANEL CLEAR	52	CLEAR PANEL	68
HOLD/NORMAL ENTRY	52	INPUT GROUP	69
DISPLAY PROCEDURES	53	ACCEPT GROUP	70
POSITION	54	WITH ACCEPT LIGHT	70
ETE-CSE	54	STATION PAIR	71
RANGE-BRG	54	INPUT EAST OR WEST	72
LOP	55	ARGUMENT INPUT	73
STATUS	55	------ DIGITS	74
COMPLETE	56	DISPLAY CONVERSION	78
NCTR	57	BCD TO BINARY	83
COH	58	(MAKE TWO BINARY)	85
INSERT PROCEDURES	59	LAT/LONG SCALING	86
END BY ACCEPT	56	BINARY TO BCD	87
POSITION	60	MAKE LAT/LONG	88
D-GMT	62	MAKE RANGE & BEARING	89
MAN V/H	63	VAR SAVE	91
RZ V/H	63	VELOCITY MAGNITUDE	92
OMEGA STATION SELECT	64	POSITION VECTOR	93
		SLOW (NON OMEGA TASKS)	94
		RZ POS UPDATE	95
		RZ TIME UPDATE	96

3.2.1 PANEL INPUT Description

PANEL INPUT is the Interrupt Routine. It processes all control/indicator interrupts which are activated by the depression of a panel button. It is also entered after panel test.

It is this interrupt routine which provides the interface between the operator action and the routine processing of the PANEL MAIN routine (Section 3.1). PANEL INPUT manipulates the panel lights, checks the validity of operator procedures, tracks the procedures when a series of operator actions are required and puts data in the proper form for processing. To accomplish this, much use is made of the Panel Pin Subroutines.

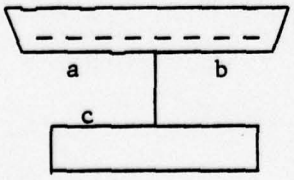
3.2.2 Panel Pin Subroutines

The panel pin subroutines are used extensively by the Panel Interrupt Routine. They were devised as a programming convenience as a result of the unique and advanced design of the NDC-1070 computer. The necessity for their use is due to the fact that the input/output procedures are sequentially dependent on the action of the operator.

In the operational OMEGA program the push-down stack is used. This hardware device led to the interleaved program sequencing concept (see Volume II) which normally has many routines at some point of processing simultaneously (this does not say that they are being processed simultaneously). However, the processing time of these routines of the OMEGA software are well known so that each is finished within sufficient time of the data constraints.

The Panel Interrupt Routines cannot be handled in the push-down stack since the timing of many of the procedures depends upon when the omega operator decides to push the next button. This delay is not tolerable to the push-down stack concept. Consequently, the Panel Pin Subroutines use two memory registers; LINKWORD for the Accept Group Subroutines, and PROCWORD for the Input Group Subroutines. This is displayed in Table 2. The difference between the groups is that an Accept Group subroutine can use an Input Group Subroutine, but this is not reversible.

The Panel Pin Subroutine is designated as a user defined block in the Flow Diagrams:



Panel Pin Subroutine Designator

where a will be INPUT or ACCEPT
b will be a Panel Pin Subroutine
c is never printed but here represents the memory address of the next instruction after the Panel Pin Subroutine designated above it.

TABLE 2 PANEL PIN SUBROUTINES AND PROGRAM LABELS

GROUP	PROCESS NAME	SUBROUTINE ENTRY	REGISTER
INPUT	UPPER LEFT KEY	PANOUT	PROCWORD
	UPPER RIGHT KEY	PANOUT $7	
	LOWER KEY	PANOUT $1	
ACCEPT	WITH ACCEPT LIGHT	OUTWAL	LINKWORD
	TWO DIGITS	INSTWO	
	THREE DIGITS	INSTHREE	
	FIVE DIGITS	INSFIVE	
	SIX DIGITS	INSSIX	
	EAST OR WEST .	ENTEREW	
	LEFT STATION PAIR	STAPAIR	
	RIGHT STATION PAIR	STAPAIR$1	
	ARGUMENT	ARGINPUT	
(MISC)	CLEAR PANEL	PANEL PIN $2	(NONE)

Panel Pin Subroutines, page 67, Flow Diagrams

The address, c, will be stored in LINKWORD or PROCWORD depending upon whether label a is ACCEPT or INPUT respectively. The program then branches to the appropriate Panel Pin Subroutine and executes. Sequencing may or may not return to the address in the LINKWORD register prior to exit. At the next Panel Interrupt sequencing is initiated at the address in PROCWORD. The use of the Panel Interrupt Routine with the Panel Pin Subroutine is given in Table 3, which is an example of a first-time, date and time insert.

TABLE 3 EXAMPLE PROCEDURE

ASSUMPTIONS: 1) Operator desires to insert date and time into the program.
2) It is the first such entry.
3) The INSERT lamp is activated on the Control-Indicator Panel.

OPERATOR ACTION	PROCEDURE CALLED	SUB-PROCEDURE	LABEL	(page) FLOW DGM	DESCRIPTION OF FUNCTIONS PERFORMED	REGISTERS	
						LINKWORD	PROCWORD
Depress INSERT Button	PANEL INTERRUPT		PANEL INPUT	49	1) Checks interrupt signal for validity. 2) Checks whether lower 15 keyboard was activated. 3) Finds Switch Select procedure in table p50/$2 table. 4) Transfers control to Insert/Accept procedure.		
		INSERT	INSACC	59	1) Detects that it is Insert and not Accept. 2) Sets up valid control panel lamp signals from which operator may select appropriate insert procedures: POS. , D-GMT, MAN-H/S. 3) Call Panel Pin Subroutine, Input, Lower Key and save address of next instruction (this routine) in the PROCWORD register.		p59/6
	PANEL PIN		PANEL PIN	66	1) Checks for Clear or Accept, then branches to Panel Output procedures.		
		PANEL OUTPUT	PANOUT	69	1) Set up Switch Mask to be used to check validity of operator inserted data. 2) Turn on all Panel lamps selected by INSACC 2) above. 3) Exit Panel Interrupt routine		
					(See footnote 1)		
Depress D-GMT	PANEL INTERRUPT		PANEL INPUT	49	1) Checks validity, then finds that signal is a Lower 15 Keyboard entry. This implies a procedure in progress. Transfers to address held in PROCWORD.		p59/6
		INSERT	INSACC	59	4) (continued via PROCWORD). Detects button #8 and selects the D-GMT procedure.		
		D-GMT	$9	62	1) Checks to see if first TIME insert. (It is assumed here that it is.) 2) At this point there is a potential branch. It may be that operator desires to use old date and time. If so, he presses ACCEPT	p63/3	

TABLE 3 (Continued)

OPERATOR ACTION	PROCEDURE CALLED	SUB-PROCEDURE	LABEL	(page) FLOW DGM	DESCRIPTION OF FUNCTIONS PERFORMED	REGISTERS	
						LINKWORD	PROCWORD
					button which effectively ends procedure. It is assumed here that new date and time are entered. Call Panel Pin routine: Accept, With Accept Light, and save address of next instruction, this routine, in LINKWORD register.		
	PANEL PIN		PANEL PIN	66	1) Checks for CLEAR or ACCEPT, then branches to Accept, With Accept Light procedure.		
		WITH ACCEPT LAMP	OUTWAL	70	1) Turn on ACCEPT Light, put appropriate digit in switch mask. 2) Branch to PANEL-PIN subroutine: Input, Upper Left Key, and save address of the next instruction of this routine in PROCWORD. 3) Exit. (See footnote 2)		p70/3
Depresses Date and Time In Digits	PANEL INTERRUPT		PANEL INPUT	49	1) Checks; find lower 15 Keyboard entry; transfers to address in PROCWORD register.		
	PANEL PIN	WITH ACCEPT LAMP	OUTWAL	70	4) (continued via PROCWORD). ACCEPT Lamp Turned Off with entry of first digit. Display cleared. 5) Transfer to address in LINKWORD register.		
	PANEL INTERRUPT	INSERT D-GMT	$9	63	3) Store 63/$92 in LINKWORD register. 4) Transfer to DIGIT INPUT procedure to manipulate incoming data.	p63/$92	
		DIGIT INPUT	INSSIX $4	75	1) Processes data of left register. 2) Transfers to LINKWORD.		
	PANEL INTERRUPT	INSERT D-GMT	$92	63	1) Call Panel Pin Routine - Accept, Six Digit Routine.		
		DIGIT INPUT	INSSIX $4	75	1) Processed data on right register. 2) Call Panel Pin - Accept, with Accept Light	p77/$8+1	

TABLE 3 (Continued)

OPERATOR ACTION	PROCEDURE CALLED	SUB-PROCEDURE	LABEL	(page) FLOW DGM	DESCRIPTION OF FUNCTIONS PERFORMED	REGISTERS	
						LINKWORD	PROCWORD
					and store in LINKWORD. The address of the instruction which will initiate the input error routine if operator should push any other button but ACCEPT.		
	PANEL PIN	WITH ACCEPT LAMP	OCTWAL	70	1) Turn on ACCEPT Lamp. 2) Call Panel Pin subroutine: Input, Upper Left Key.		
		INPUT LOWER LEFT KEY	PANOUT	69	1) Exit. (See footnote 3)		
Depress ACCEPT	PANEL INTERRUPT		PANEL INPUT	49	1) Call Insert procedure.		
		INSERT	INSACC	59	1) Test for ACCEPT. 2) Branch to Display procedure complete.		
		DISPLAY	DISFINAL$4	57	1) Turn off ACCEPT, take ACCEPT digit out of Switch Mask. 2) Set up date to be used in appropriate non-OMEGA task routine. 3) Dummy transfer to Panel Pin - Input, Lower Key.		
	PANEL PIN		PANEL PIN		1) Check and transfer to Input, Lower Key and save address of next instruction of this routine in PROCWORD register.		p56/$3+1 (not used)
		INPUT LOWER KEY	PANOUT$1	69	1) Exit.		

FOOTNOTES

1) Computer Program returns to the program processing of that function which was halted by the Panel Interrupt. The Panel Interrupt routine is now waiting for the next button to be depressed and will continue the procedure.

2) Computer Program returns to the processing of whatever function was halted. Panel is now waiting for another button to be depressed to continue procedure.

3) Computer Program returns to function halted by Panel Interrupt. The panel interrupt routine is now waiting for the ACCEPT button to be depressed and will END the procedure.

3.2.3 Description of PANEL INPUT Routines

3.2.3.1 Panel Interrupt Procedures

The Panel Interrupt Routine, pages 49-51, may be thought of as a panel executive routine. It is entered whenever a panel interrupt occurs, which is to say, whenever a button is depressed. The sequence of the routine is as follows:

a) Is the panel in the test mode? If so, continue testing.

b) Is the depressed button valid? If not, call Panel Pin Routine; Subroutine Clear Panel. If so, continue.

c) Is the depressed button one of the 15 lower keyboard keys? If so, then this means that a procedure is already in progress, and that the address of the next instruction in that procedure is contained in the register designated as PROCWORD. If not, continue.

d) Since it is none of the above then it must be that a new procedure is being initiated; either CLEAR, DISPLAY, ACCEPT/INSERT, HOLD/NORMAL, LOOP/FLOAT or PANEL TEST. In this case the panel interrupt routine branches to the appropriate routine as indicated in Table 4.

TABLE 4 INTERRUPT PROCEDURE MAP

This map yields the flow diagram page upon which the indicated routine can be found.

1) CLEAR depressed (or failure of validity test); Panel Pin Subroutine: CLEAR PANEL, page 68.

2) HOLD/NORMAL depressed; Panel Input Subroutine: HOLD/NORMAL entry page 52.

3) PANEL *test depressed; see* Volume XI, 3.1.2 (h).

4) DISPLAY depressed; Display Procedures: pages 53 to 58 (Table $10)

TABLE 4 (Continued)

ROUTINE	PAGE	ROUTINE	PAGE	ROUTINE	PAGE
POS	54	R-BRG	54	INPUTS	56*
STATUS	55	ETE-CSE	54	NCTR	57
RZ-POS	54	COH	57	RZ H/S	54
POS VAR	56*	D-GMT	56*	AUTO H/S	56*
LOP	55	MAN H/S	54		
LOOP/FLOAT	50				

* Each routine processed by DISFINAL routine since no other action is necessary.

5) INSERT depressed; Insert Procedures: pages 59 to 65 (Table $7)

ROUTINE	PAGE	ROUTINE	PAGE
POS	60	INPUTS	64
D-GMT	62	RZ- H/S	63
MAN H/S	63		

a) Panel Clear (page 52): This routine places panel in the quiescent state and turns on INSERT and DISPLAY indicators.

Panel Test: Initiates panel test (discussed in Built-in-Test).

b) Hold/Normal Entry: At the time the HOLD button is depressed the HOLD MRK is set true and the data indicated below is transferred, as is, to special registers whence they may be displayed as desired. The star on the variables represents data in the HOLD mode. If the HOLD button is not depressed and any of the below data is displayed, that data will change on the display reflecting normal updating. At the time the NORMAL button is depressed the HOLD MRK is set false.

R^*_{ij} Current submarine position

V^*_{ci}, ψ^*_A Calculated velocity and track angle

V^*_{TAS}, ψ^*_A Ship's E.M., log and, if not in MAN mode, MK 19 heading

R^*_{Di}, ψ^*_{Di} Range and bearing to selected destination i

ETE^*_i Estimated time to selected destination i

DATE*, GMT* Date - Greenwich Mean Time

c) Display Procedures (page 53): When the panel interrupt routine determines that a display procedure has been initiated then the sequencing branches to DISTART. This procedure will prepare the panel by turning off INSERT, ACCEPT and DISPLAY indicators and turning on the lower 15 keyboard indicators.

The address of the next instruction, page 53 /DISTART+4, is saved in PROCWORD and the routine is exited. The operator at his convenience, will then choose a display, the Panel Interrupt Routine will branch to the address in PROCWORD and one of the procedures in Table $10 on page 53 will be initiated. These procedures are described next.

d) Panel Interrupt:

1) Position Display (page 54): This display procedure, combined with that of ETE-CSE display below, prepares the panel for operator selection of either submarine destination, or rendevous position. P54/$1 turns on SUB indicator.

2) ETE-CSE (page 54): The indicators 0-9 and RZ are activated, address of P54/$33+1 is saved in LINKWORD, and a panel pin subroutine is used to set up ARG1 for whichever of the proper buttons is depressed. The Argument Input subroutine uses another Panel Pin Subroutine, Input-Upper Left Key, to exit; also, saving the address of P73/2 in the PROCWORD register. Upon depression of one of the illuminated indicators the sequencing will return via PROCWORD to P73/2, thence via LINKWORD to P54/$33+1 and precedure complete.

3) R-BRG Display (pages 54,55): This display procedure demands a start point and an end point. The SUB, 0-9 and RZ lamps are turned on for start point selection.

Upon depression of start point it is turned off so that the operator cannot select the same point as end point. Start point is saved in ARG1 and end point in ARG2.

4) LOP Display (P55/$5): This procedure immediately calls Accept Left Station Pair which will turn on station lamps and exit while waiting for operator to select a station. The LINKWORD register is used to return to P55/$5+1, but prior to that the PROCWORD register is used to return sequencing to the Station pair subroutine which turns off

the indicator just depressed to prevent operator from selecting the same station for the second entry.

When the operator selects the second station the sequencing returns to P55/$5+1 via LINKWORD and the same procedure is followed for the right station pair.

Upon completion the procedure continues through that of STATUS display at $55.

5) Status Display (Page55): Turns on the 0, 1, 2, INPUTS AND COH indicators for desired selection. Upon depression of selected frequency the routine saves it in ARG1, then exits via DISFINAL. If INPUTS is selected the test failures are displayed (See Vol XI). For COH see Page 57.

6) Display Procedure Complete (Page 56): These panel interrupt procedures administer the data input and the procedural demands of the operator. However, they do not process data. Consequently, the first task here, P56/DISFINAL, is to flag the display routine desired by the operator. The routine is now selected by the non-Ω-task table and the data will be processed by the procedures discussed in PANEL MAIN.

The selected display procedure is illuminated on the panel for operator convenience as is INPUT and DISPLAY indicators.

Panel interrupt routine is exited here.

7) NCTR Display (Page 57): Turns on all station indicators. Uses Panel Pin, input upper test key, routine to handle station data.

8) COH Display (Page 58): Turns on all station indicators. Uses Panel Pin, input upper test key, routine to handle station data.

é) Insert Procedures (Pages 59-60):

When the panel interrupt routine determines that an insert procedure has been initiated (i.e., INSERT/ACCEPT button depressed) then the sequencing branches to INSACC. All insert procedures are initiated and controlled here.

If the ACCEPT button was depressed then sequencing branches to P57/$4 which ends an insert procedure (discussed above).

If the insert button is depressed then ACCEPT, INSERT and DISPLAY are turned off and the insert procedural indicators turned on. Upon depression of an insert procedure the sequencing branches to one of the items of Table $7 on Page 59/(bottom).

1) Insert End by depressing Accept (p56-57)

This procedure will end an insert procedure and set up the selected routine for processing by the non-Ω-task table.

2) Position Inserts (pages 60-61)

The three types of position inserts, i.e., submarine, destination or rendezvous, are included in the position insert procedures.

p60/$1 to $19: Craft position (Sub or Rz) cannot be entered until the ET lamp is off.

Once it has been determined that a vehicle position is to be inserted then the branch at p61/1 will mark it as a special insert routine for the Panel Pin Subroutines, Accept Group-digit input (page 74). This routine will permit a position quality insert prior to illuminating the accept lamp.

3) D-GMT insert p62/$9 - p63/$92

This procedure is completely documented as an example in Table 3, document pages 74-76.

Pages 63 through 65

The following procedures are short and adequately explained by the flow diagram.

	Procedure	Flow Diagram Page
4)	MAN RZ H/S	63
5)	OMEGA STATION SELECT (INPUTS)	64

f) Panel Pin Subroutines, page 66, 67

p66/PANEL PIN. At any time a Panel Pin subroutine is called, this is the entry point.

The Panel Pin subroutine checks first for the CLEAR subroutine, in which case a branch to p67/$2 will clear the panel.

If not then a check is made to find out if the routine selected by the calling routine is in the ACCEPT group. If so the return address to the calling program is saved in the LINKWORD register. If not then it must be a routine in the INPUT group in which case it is saved in the PROCWORD register.

Note that even though that address saved in the LINKWORD is also saved in PROCWORD that there is no conflict as the PROCWORD, if used, is always the last entry.

The routine now branches to the specific Panel Pin subroutine listed in the table on p67.

1) CLEAR PANEL (page 68)

Puts program and Panel in the quiescent state.

2) Input Keyboard Button p69

This routine is used to exit the Panel Interrupt routine while a procedure is in progress. This routine is the INPUT group of Panel Pin Subroutines:

Subroutine	Entry
INPUT UPPER LEFT KEY	PANOUT
INPUT UPPER RIGHT KEY	PANOUT #4
INPUT LOWER KEY	PANOUT #1

There are three registers whose bits control the indicators; one for the upper left indicators, one for the upper right indicators and the other for the lower indicators. The switch mask will combine all positive bits into a mask such that when a button is depressed on the panel the Panel Interrupt routine can check the button against the switch mask as a validity check. The switch mask is formed here.

All indicators turned off or on by other procedures are activated or deactivated here.

3) ACCEPT - WITH ACCEPT LIGHT (page 70)

There are many procedures which have the option of inserting data or accepting that data which has been input or generated previously. This subroutine controls the sequencing. The routine uses INPUT-UPPER LEFT KEY subroutine to exist, saving the address of p70/3 in the PROCWORD register as a return if the ACCEPT button is not depressed.

Upon depression of any other button the sequence returns to p70/3 where the ACCEPT indicator is turned off, accept bit is deleted from the switch mask, the display of the old data is cleared, and the return to the procedure is via LINKWORD.

4) ACCEPT STATION PAIR (page 71)

This routine in the Accept Group is used by the LOP Display Procedure to allow the operator to select a pair of stations and display the selected pair in the Legends.

5) ACCEPT INPUT EAST OR WEST (page 72)

Allows the operator to select East or West Longitude and Display the E or W in the Right Display Legend.

6) ACCEPT ARGUMENT INPUT (page 73)

This routine will execute an "input-upper left key" and save the button number in ARG1 and the lamp bit in image 11. It is used by procedures that want to pass the button number (upper left) to the display or insert routines.

7) ACCEPT - DIGITS (page 74-77)

Processes strings of 2, 3,5 and 6 digits. It assumes that the last digit in goes into the right most digit of the display and all others are placed accordingly. It will look for the "SPECIAL INSERT" flag and request a position quality insert from operator prior to turning on ACCEPT lamp.

g) Display Conversion Routine (page 78)

This routine will convert data to BCD for display and set up the legend. The flow diagram presents more details.

Reference to this subroutine in the flow diagrams is by a subroutine call designator, with the word GEN lower left and the specified data printed lower right. This subroutine is used at the following locations:

p18/4,6	p42/5	p90/1
p19/4,5		
p24/2	p45/2	
p23/2	p46/2,4	
p36/6	p47/2,4	

h) BCD to Binary page 83-85

There are two subroutines here: BCDTOBIN and MAKE TWO BINARY.

BCD TO BIN: This routine will convert the 6 character display image to binary with the least significant bit of binary word equal to 1 count in the least significant digit of the display.

MAKE TWO BINARY: This routine will convert two BCD characters to binary.

i) Latitude/Longitude Scaling

This routine takes latitude and longitude that has been converted to binary and changes it to radians scaled pi after correcting for South latitude and West longitude.

j) Binary to BCD

Converts a binary number (less than 100) scaled B15 to two BCD characters that are placed in the 2 low digits of a 32-bit register and then shifted left 2 digits.

k) Make Lat Long

Computes latitude and longitude from a position vector.

Lat = TAN^{-1} $(R1/(R_3^2 + R_2^2)^{\frac{1}{2}})$

Long = TAN^{-1} (R3/R2)

l) Make Range and Bearing

Computes range and bearing between two points and converts the bearing for display.

P89/Make Range and Bearing

Find the destination end point D.

P89/4

Determine the start point. Find latitude & longitude

P89/$2

$$\psi_{Di} = -TAN^{-1}\left(\frac{\hat{R}_2 \cdot \hat{D}_i}{\hat{R}_3 \cdot \hat{D}_i}\right) - \theta_p$$

$$R_{Di} = TAN^{-1}\left(\frac{|\hat{D}_i \times \hat{R}_1|}{\hat{D}_i \cdot \hat{R}_1}\right)$$

m) VARSAVE

Transfers the craft related data used by the various display programs into a special storage area. This is primarily for the HOLD routine.

Transfers: R_{ij}, V_{sea}, V_{log}, TIME, V_{c2}, V_{c3}, θ_p, ψ_A.

n) Velocity Magnitude

Computes the magnitude of the two element velocity vector arguments.

$V(mag) = (V_2^2 + V_3^2)^{\frac{1}{2}}$

o) Position Vector

Computes a 3-element position vector from latitude and longitude arguments

λ = latitude

L = longitude

then

R1 = Sin (λ)

R2 = Cos (λ) cos (L)

R3 = Cos (λ) Sin (L)

p) SLOW Non-Ω - Tasks

The SLOW routine is a non-Ω-task that has a ten-element table. One element of the table is processed at each calling of SLOW. Five of the table entries are dummy entries causing an immediate return. The other five are OPER-P-C , RZ-position update, RZ-time update, GP-Test, and OSC-Test. Each is processed once per second in the SLOW routine whether they are called for display or not. The last two test routines are described in Volume XI, TESTS.

1) OPER-P-C is a routine useful only when the Programmer Controller is connected to the system. A test failure display in its LED lights and a GO NO/GO condition is displayed. See Volume XI.

2) RZ-Position Update

This routine will be done whether the position and velocity data for a moving destination was inserted or not. Refer to Moving Destination data, pages 14 and 15 of flow diagrams. As before, the following equivalences are noted.

Flow diagrams	Equations
RZ POS	$\vec{D}_E$
RZ RATE	V_β
EARTH RADIUS	ρ_D
RZ VEL	V_D
BETA	$\vec{\beta}_E$

Obtain earth radius ρ_D of moving destination at current position.

$\rho_D = \rho_o(1 - K \cdot D_{E1}^2)$; ρ_o is equatorial radius of earth

K is a constant

$$V_\beta = \frac{V_D}{\rho_D}$$

$$\vec{D}_E = \vec{D}_E + V_\beta \, \Delta t \, (\vec{D}_E \times \vec{\beta}_E)$$

3) RZ Time Update

Upon insertion of the heading, speed and position of the second vehicle with which a rendezvous will be made, the computer program will maintain an updated position (see Insert for Moving Destination). To display the point of intercept, the following routine will use the time update equation for point of departure, which is:

$$\vec{D}_E = \vec{D}_E + V_\beta \, \Delta t (\vec{\beta}_E \times \vec{D}_E)$$

where V_β = angular velocity of moving destination along great circle course in radians/sec.

Δt = update rate of once per second

$\vec{\beta}_E$ = moving destination route with unit velocity

$\vec{D}_E$ = position of moving destination

and subscript E represents the earth-fixed reference frame

V_β = angular velocity of moving destination.

Then p96/2,3,4

$$C_{L1} = \vec{R}_1 \cdot (\vec{\beta}_E \times \vec{D}_E)$$

$$B_{L1} = \vec{R}_1 \cdot \vec{D}_E$$

p96/5

$$\gamma = TAN^{-1} (C_{L1}/B_{L1})$$

p96/6,7

$$V_S = (V_{c1}^2 + V_{c2}^2)^{\frac{1}{2}} / \rho_p$$

$$\rho_p = \rho_o (1-KSin^2 \lambda_p)$$

ρ_o = earth radius

λ_p = latitude present position

p96/8

Set $t_{(o)}$ = 5 hours

p97/1,2,3,4

Test: Is $\gamma > 0$ and $\frac{\gamma}{V_\beta} < t_{(o)}$?

If so then set $t = \frac{\gamma}{V_\beta}$

$$\Delta t = 10 - \frac{\gamma}{V_\beta}$$

Marker A = true

p97/5

if not then set t = 5 hrs, Δt = 2.5

p97/6

Main iteration loop

$\Delta t = \Delta t/2$

$f(t) = (B_{L1}^2 + C_{L1}^2)^{\frac{1}{2}} \text{Cos} (V_\beta t - \gamma) - \text{Cos} (V_S t)$

p97/7 to p98/5

Test $f(t) < 0$

If so set $t = t_{old} + \Delta t$

Reset Marker A = false

If not and

Marker A = true then set $\Delta t = \frac{t}{2}$

Marker A = false then set $t = t_{old} - \Delta t$

Reset Marker A.

p98/6

Test: Is $\Delta t > 1$ second

If so return to Main Iteration Loop p97/$1

If not then time to intercept, t_{ETE}, is available or last computed t.

p98/7

$$\alpha_\beta = V_\beta \, t_{ETE}$$

p98/8

$$\vec{\rho}_{IE} = \vec{D}_E \cos \alpha_\beta + (\vec{\beta}_E \times \vec{D}_E) \sin \alpha_\beta$$

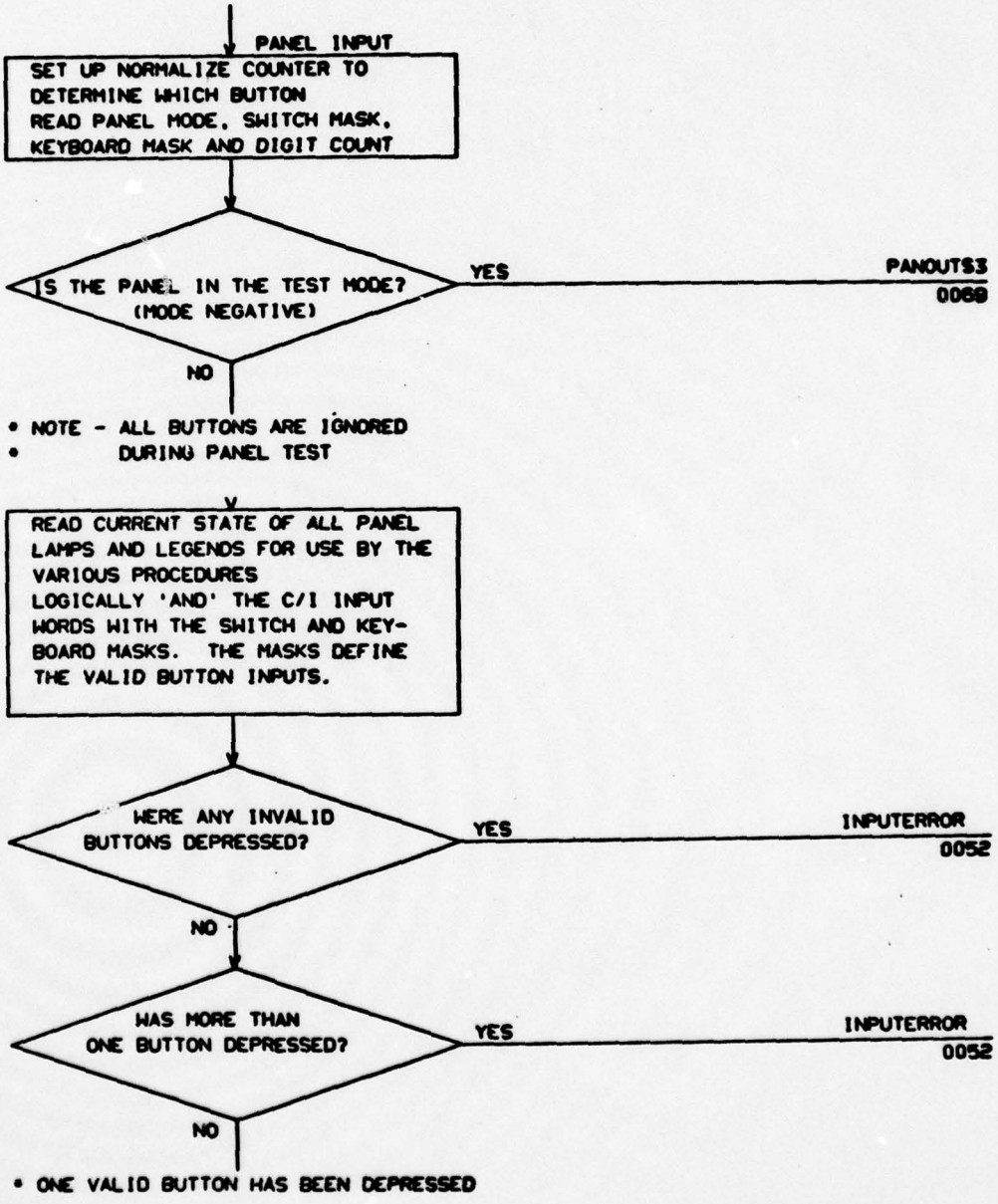
p99/2

Using the Make Latitude-Longitude Subroutine

Set $\lambda_{pI} = \text{TAN}^{-1}\left(\frac{\rho_{IE1}}{\left[\rho_{IE2}^2 + \rho_{IE3}^2\right]^{\frac{1}{2}}}\right)$

$$L_{pI} = \text{TAN}^{-1}\left(\frac{\rho_{IE3}}{\rho_{IE2}}\right)$$

```
•                          PANEL INPUT
•
• THIS PROGRAM PROCESSES ALL C/I PANEL INPUTS.  IT IS AN INTERRUPT
• ROUTINE ENTERED WHENEVER A BUTTON IS DEPRESSED ON THE PANEL.  IT IS
• ALSO ENTERED AFTER PANEL TEST.  THE PANEL INPUT WORDS WILL CONTAIN A
• BIT THAT IDENTIFIES WHICH BUTTON WAS DEPRESSED.  THIS ROUTINE CONTROLS
• ALL INSERT AND DISPLAY PROCEDURES.
•
```

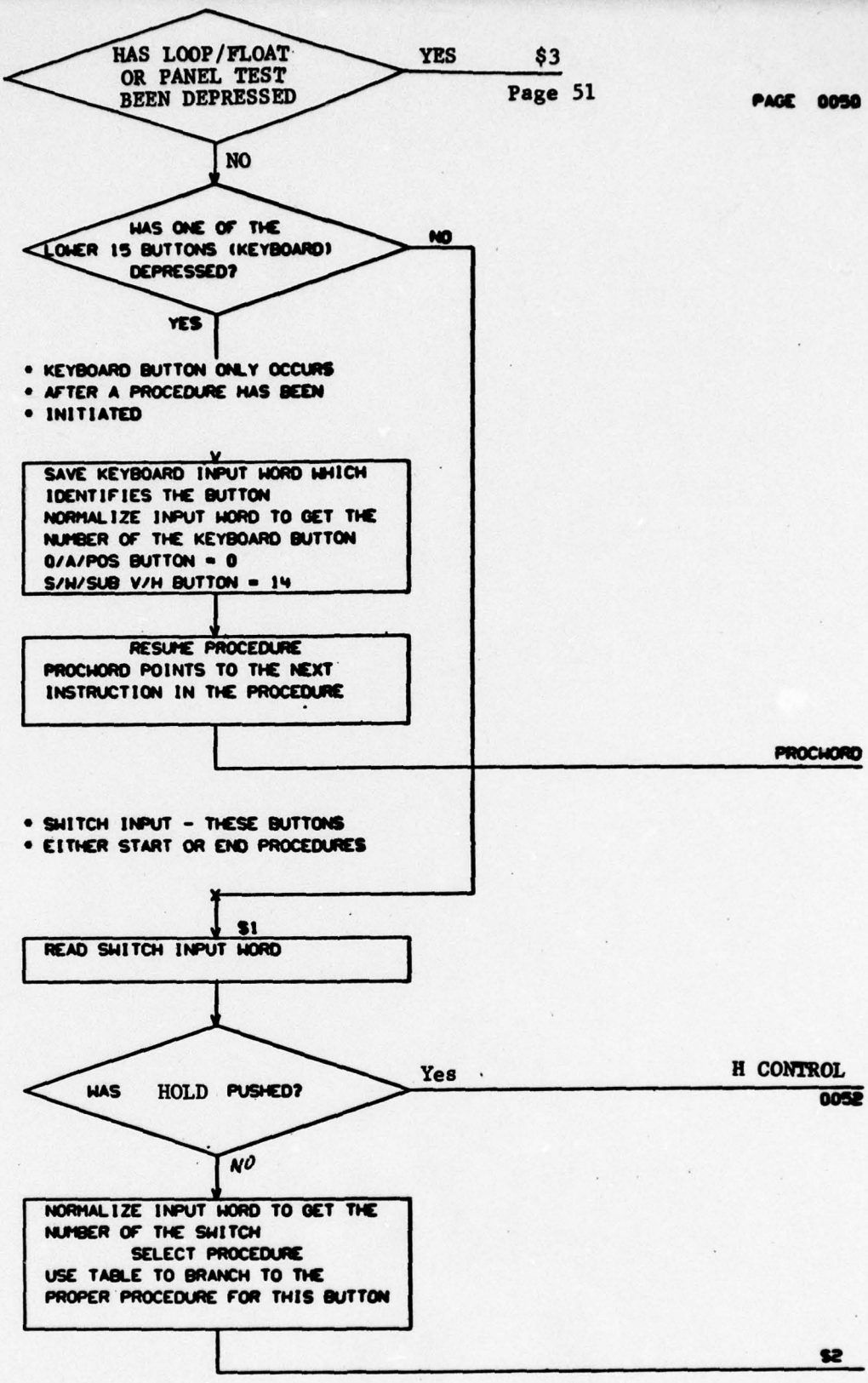


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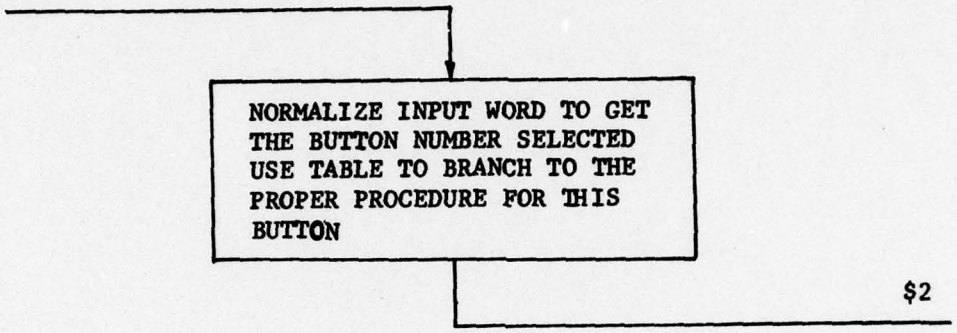
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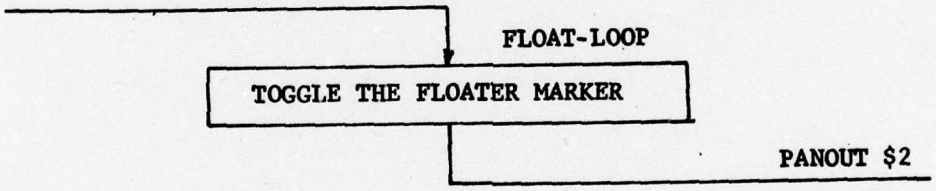


* ACCEPT/INSERT=INSACC
*CLEAR/DISPLAY=DISTART

PANEL TEST

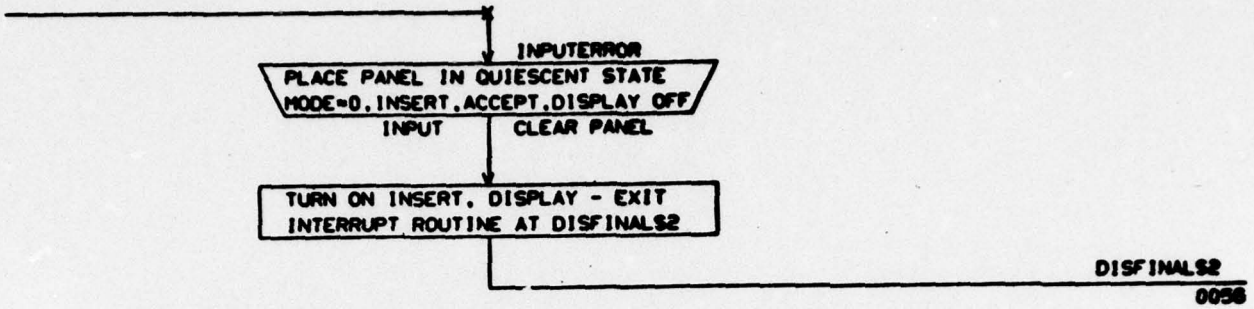
*FLOAT/LOOP=FLOAT-LOOP



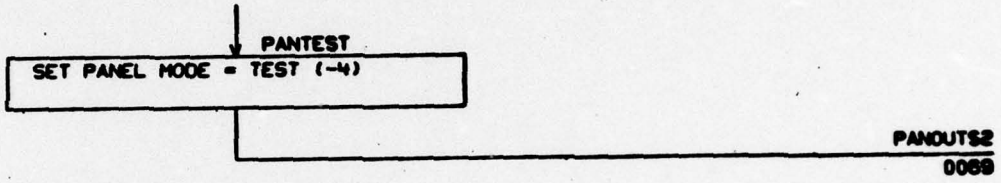


Page 69

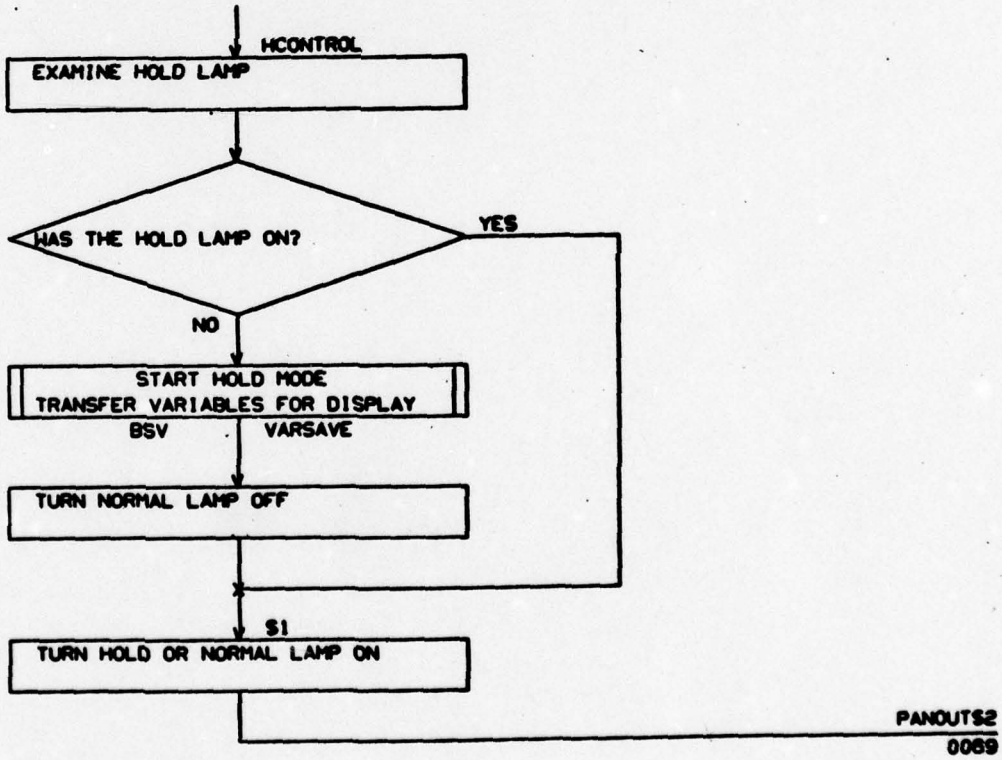
• CLEAR OR ERROR ENTRY



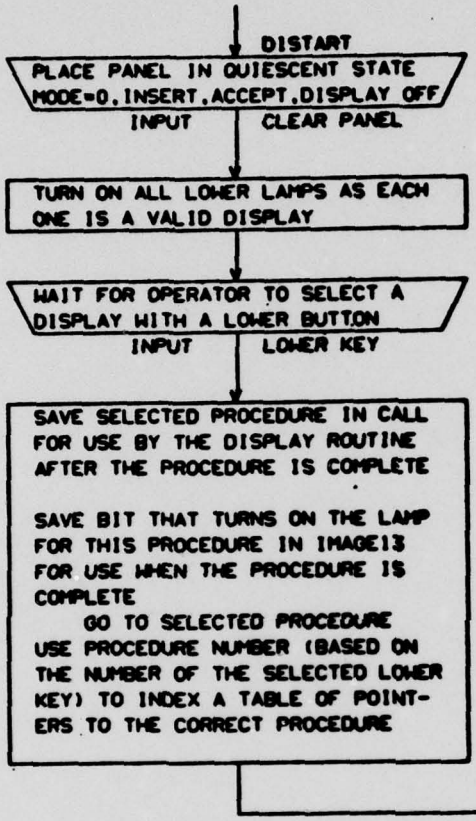
• PANEL TEST ENTRY



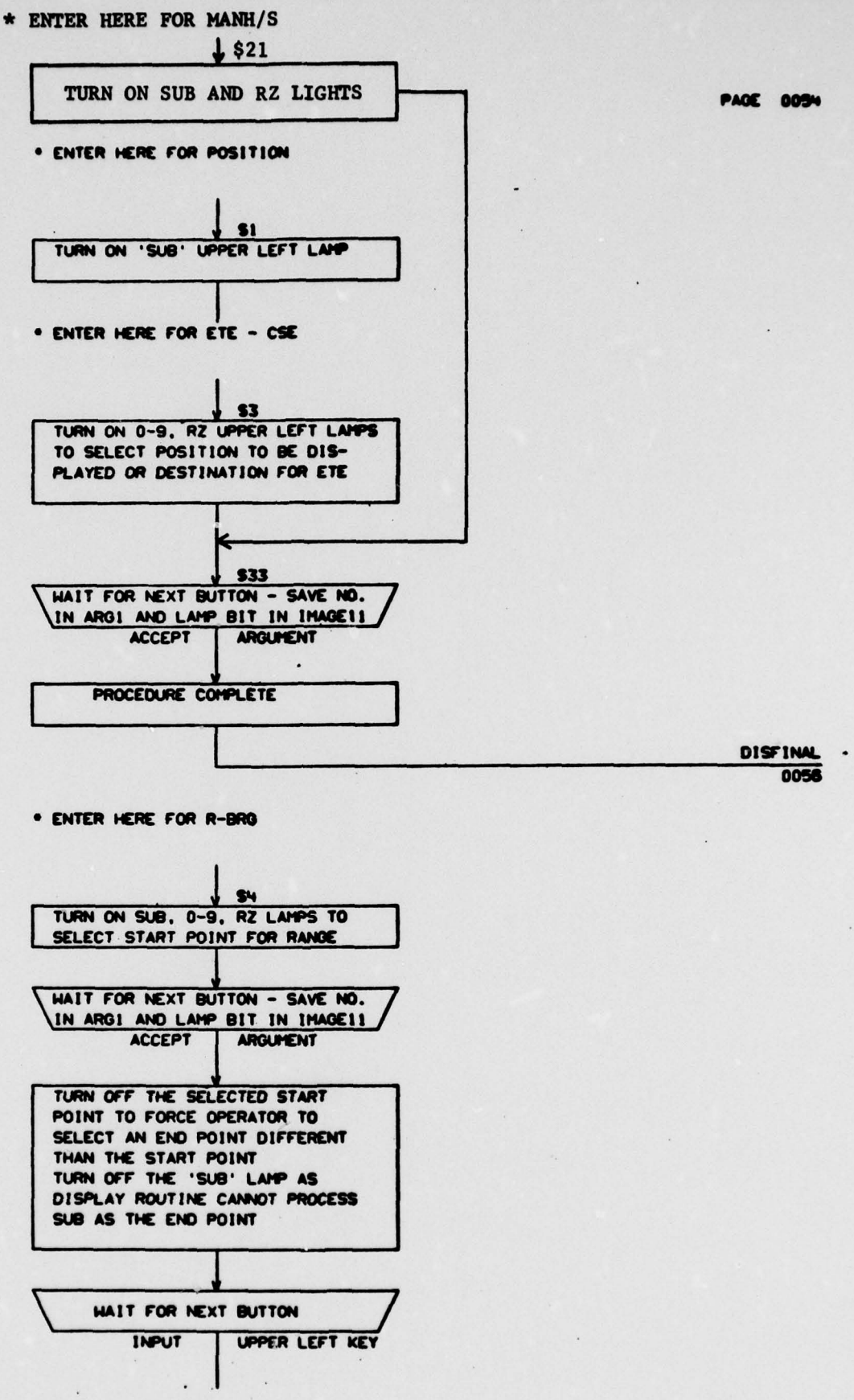
• HOLD / NORMAL ENTRY

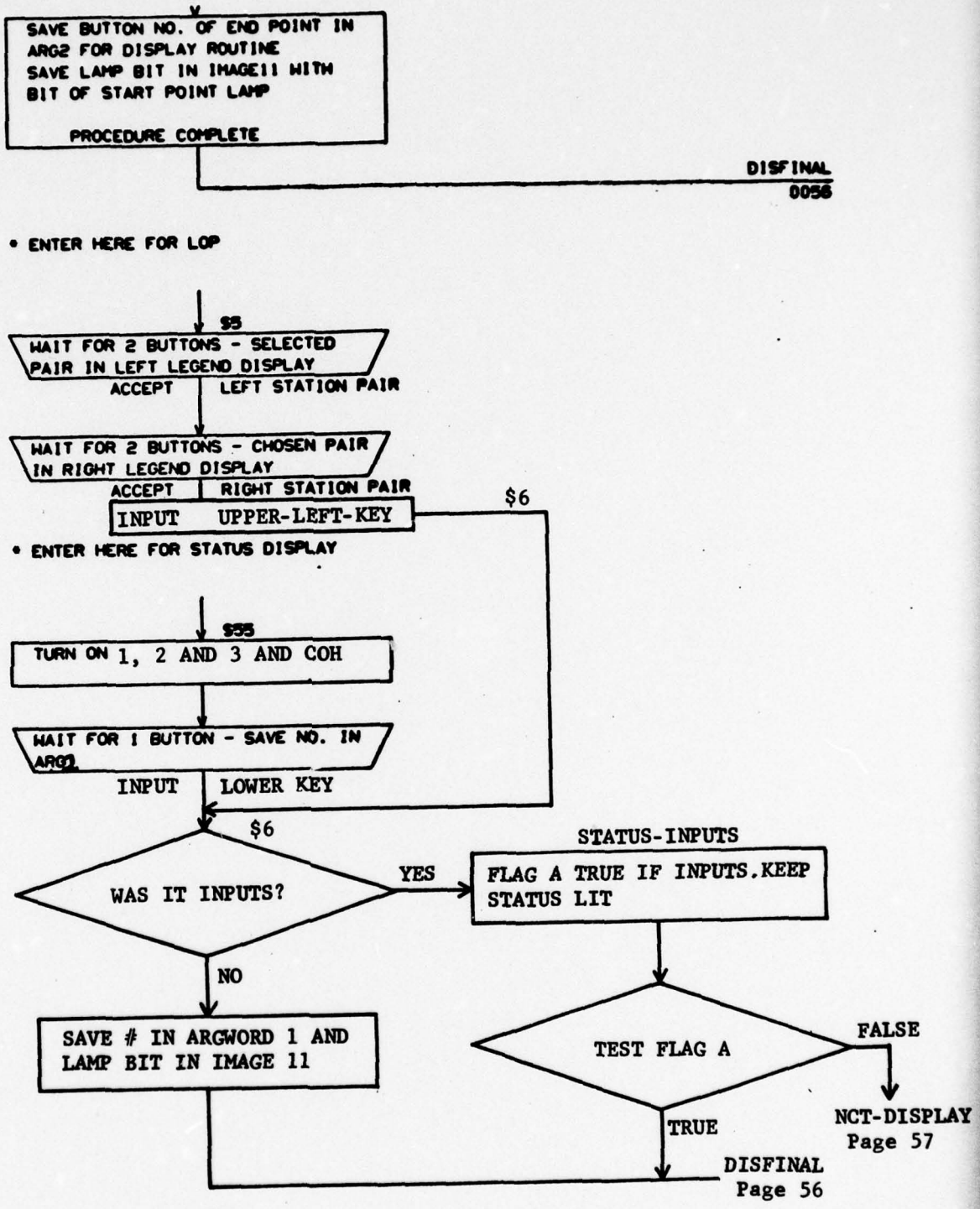


```
•
•                    DISPLAY PROCEDURES
•
• ENTER HERE WHEN THE DISPLAY BUTTON IS DEPRESSED.  ALL DISPLAY PRO-
• CEDURES ARE INITIATED AND CONTROLED FROM HERE
•
```

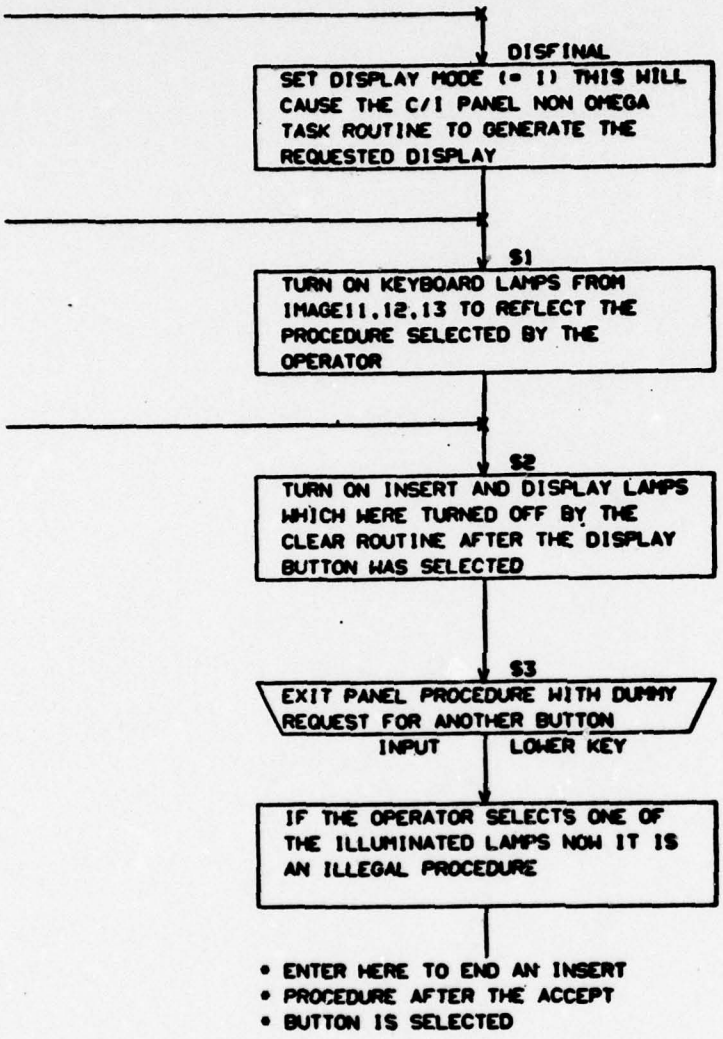



```
• EACH PROCEDURE      0 = DISFINAL   INPUTS
• WILL CONTROL        1 = $55        STATUS
• ALL OPERATOR        2 = DISFINAL   VAR
• STEPS NECESSARY     3 =            NCT-DISPLAY
• TO DEFINE THE       4 =
• DESIRED DISPLAY       =  $3        CSE-ETE
• DISFINAL INDI-      5 =  DISFINAL  D-GMT
• CATES THAT NO       6 =  $5        LOP
• FURTHER STEPS       7 =  DISFINAL  CAL H/S
• ARE REQUIRED        8 =  $21       MAN H/S
•                     9 =  DISFINAL  AUTO H/S
•                    10 =  $4        BEARING/RANGE (BRG/RNG)
•                    11 =  $1        POSITION
•                    12 =            NCT-DISPLAY  COH
```

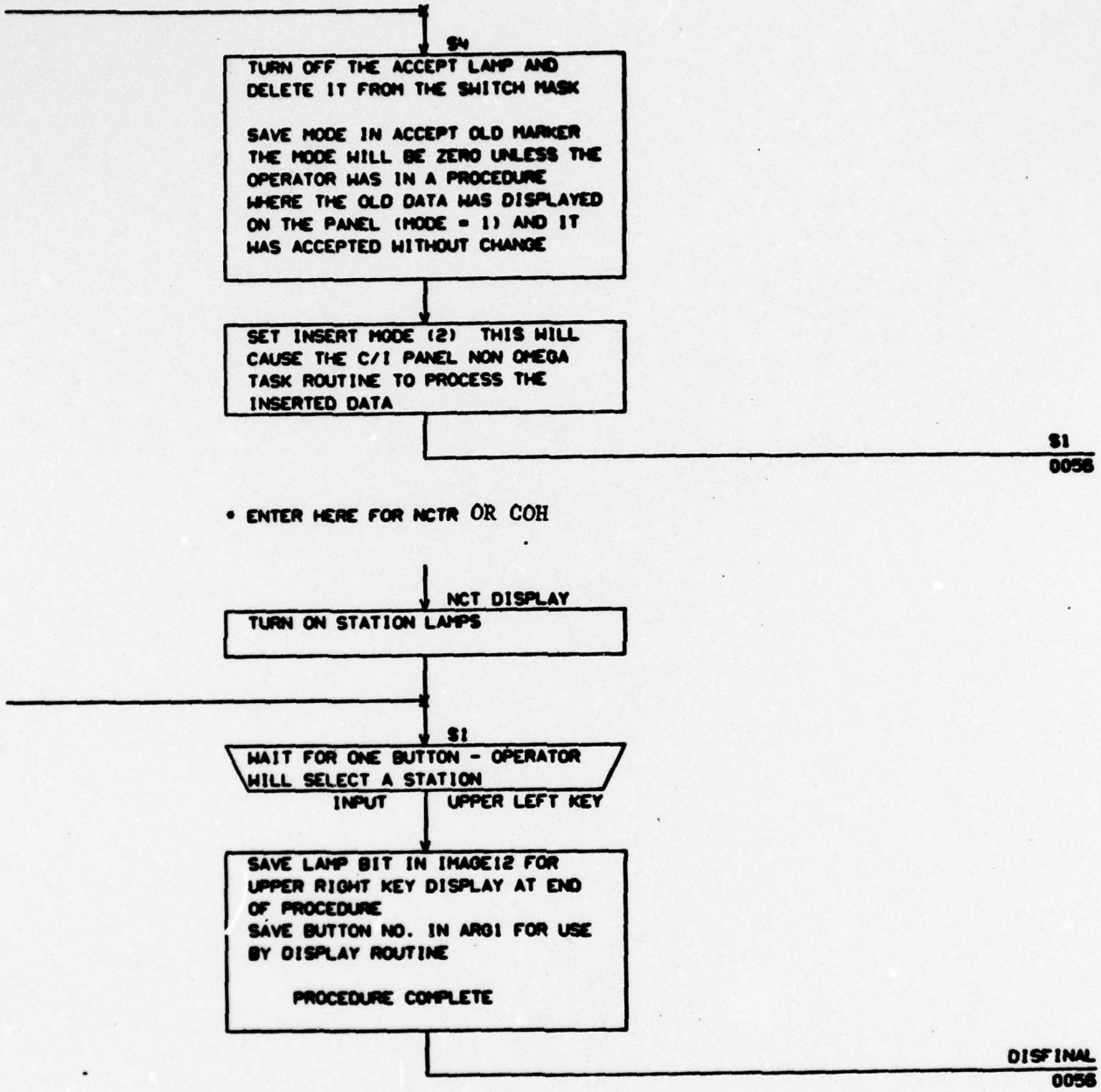

* ENTER HERE FOR MANH/S
$21
TURN ON SUB AND RZ LIGHTS
• ENTER HERE FOR POSITION
$1
TURN ON 'SUB' UPPER LEFT LAMP
• ENTER HERE FOR ETE - CSE
$3
TURN ON 0-9, RZ UPPER LEFT LAMPS TO SELECT POSITION TO BE DISPLAYED OR DESTINATION FOR ETE
$33
WAIT FOR NEXT BUTTON - SAVE NO. IN ARG1 AND LAMP BIT IN IMAGE11
ACCEPT
ARGUMENT
PROCEDURE COMPLETE
DISFINAL
0058
• ENTER HERE FOR R-BRG
$4
TURN ON SUB, 0-9, RZ LAMPS TO SELECT START POINT FOR RANGE
WAIT FOR NEXT BUTTON - SAVE NO. IN ARG1 AND LAMP BIT IN IMAGE11
ACCEPT
ARGUMENT
TURN OFF THE SELECTED START POINT TO FORCE OPERATOR TO SELECT AN END POINT DIFFERENT THAN THE START POINT
TURN OFF THE 'SUB' LAMP AS DISPLAY ROUTINE CANNOT PROCESS SUB AS THE END POINT
WAIT FOR NEXT BUTTON
INPUT
UPPER LEFT KEY


SAVE BUTTON NO. OF END POINT IN ARG2 FOR DISPLAY ROUTINE
SAVE LAMP BIT IN IMAGE11 WITH BIT OF START POINT LAMP
PROCEDURE COMPLETE
DISFINAL 0056
• ENTER HERE FOR LOP
$5
WAIT FOR 2 BUTTONS - SELECTED PAIR IN LEFT LEGEND DISPLAY
ACCEPT
LEFT STATION PAIR
WAIT FOR 2 BUTTONS - CHOSEN PAIR IN RIGHT LEGEND DISPLAY
ACCEPT
RIGHT STATION PAIR
INPUT UPPER-LEFT-KEY
$6
• ENTER HERE FOR STATUS DISPLAY
$55
TURN ON 1, 2 AND 3 AND COH
WAIT FOR 1 BUTTON - SAVE NO. IN ARG2
INPUT
LOWER KEY
$6
WAS IT INPUTS?
YES
STATUS-INPUTS
FLAG A TRUE IF INPUTS.KEEP STATUS LIT
NO
SAVE # IN ARGWORD 1 AND LAMP BIT IN IMAGE 11
TEST FLAG A
FALSE
NCT-DISPLAY Page 57
TRUE
DISFINAL Page 56

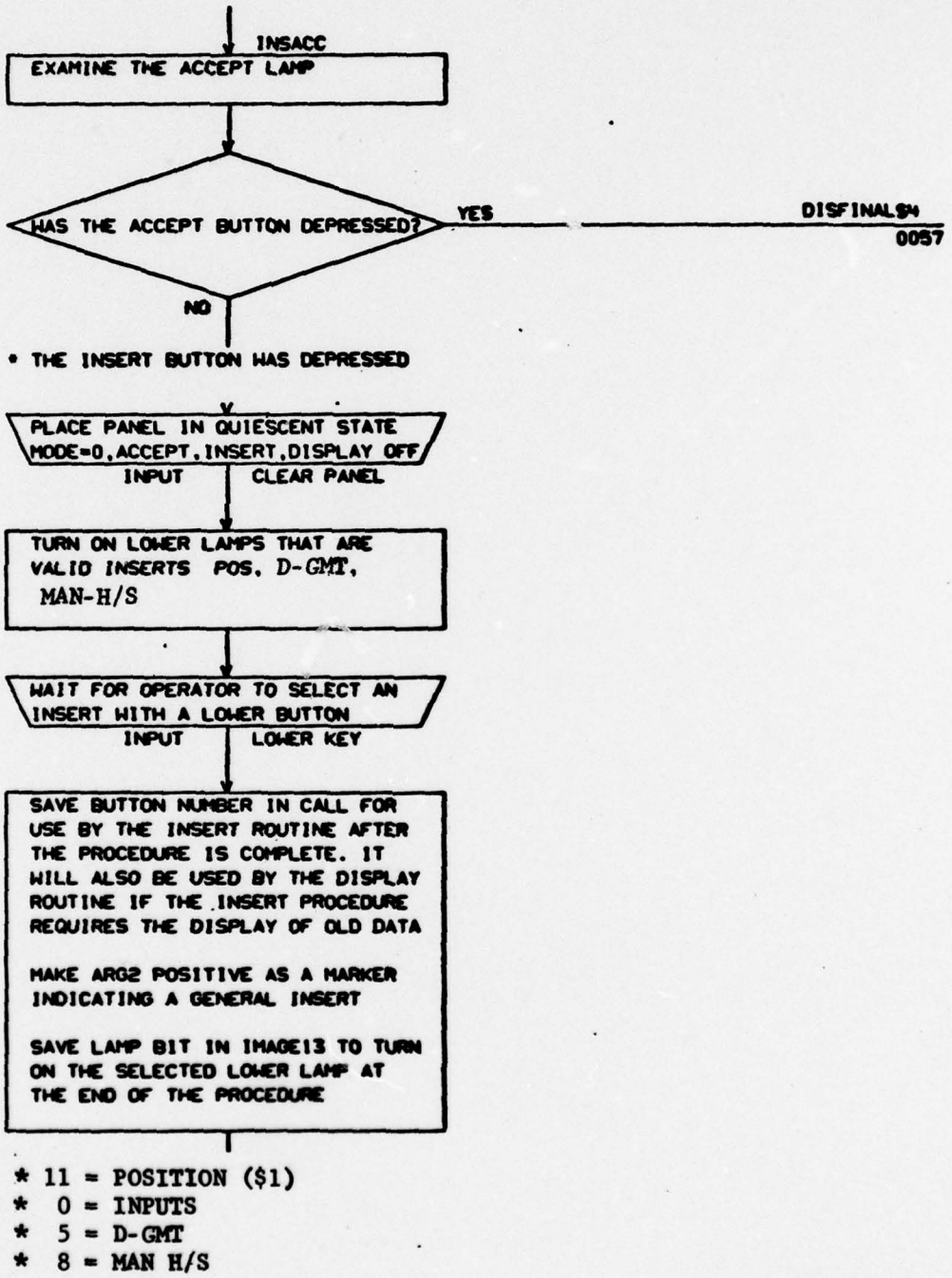
- DISPLAY PROCEDURE COMPLETE
- THIS ROUTINE IS USED TO EXIT
- THE PANEL INTERRUPT ROUTINE
- AT THE END OF A PROCEDURE



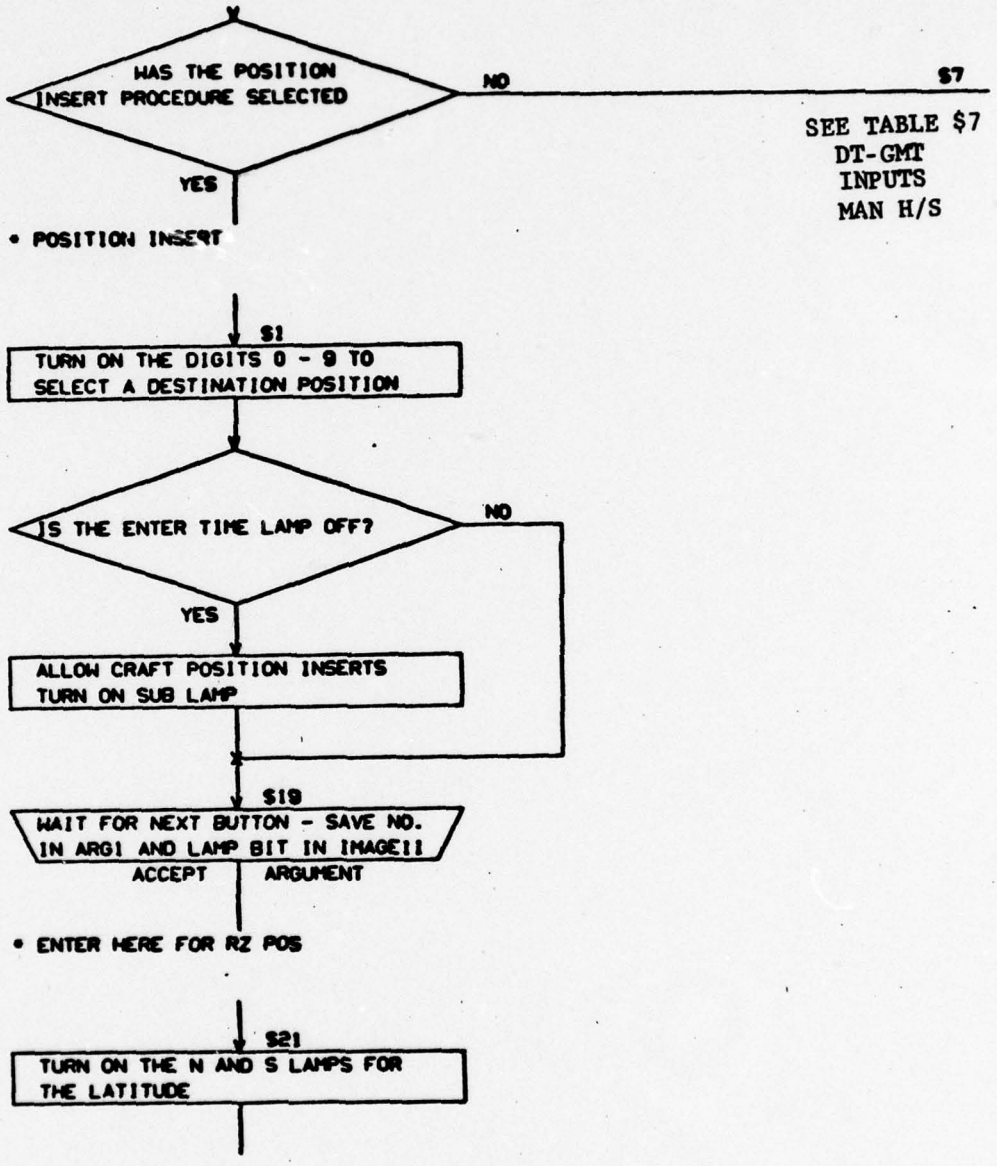
- ENTER HERE TO END AN INSERT
- PROCEDURE AFTER THE ACCEPT
- BUTTON IS SELECTED

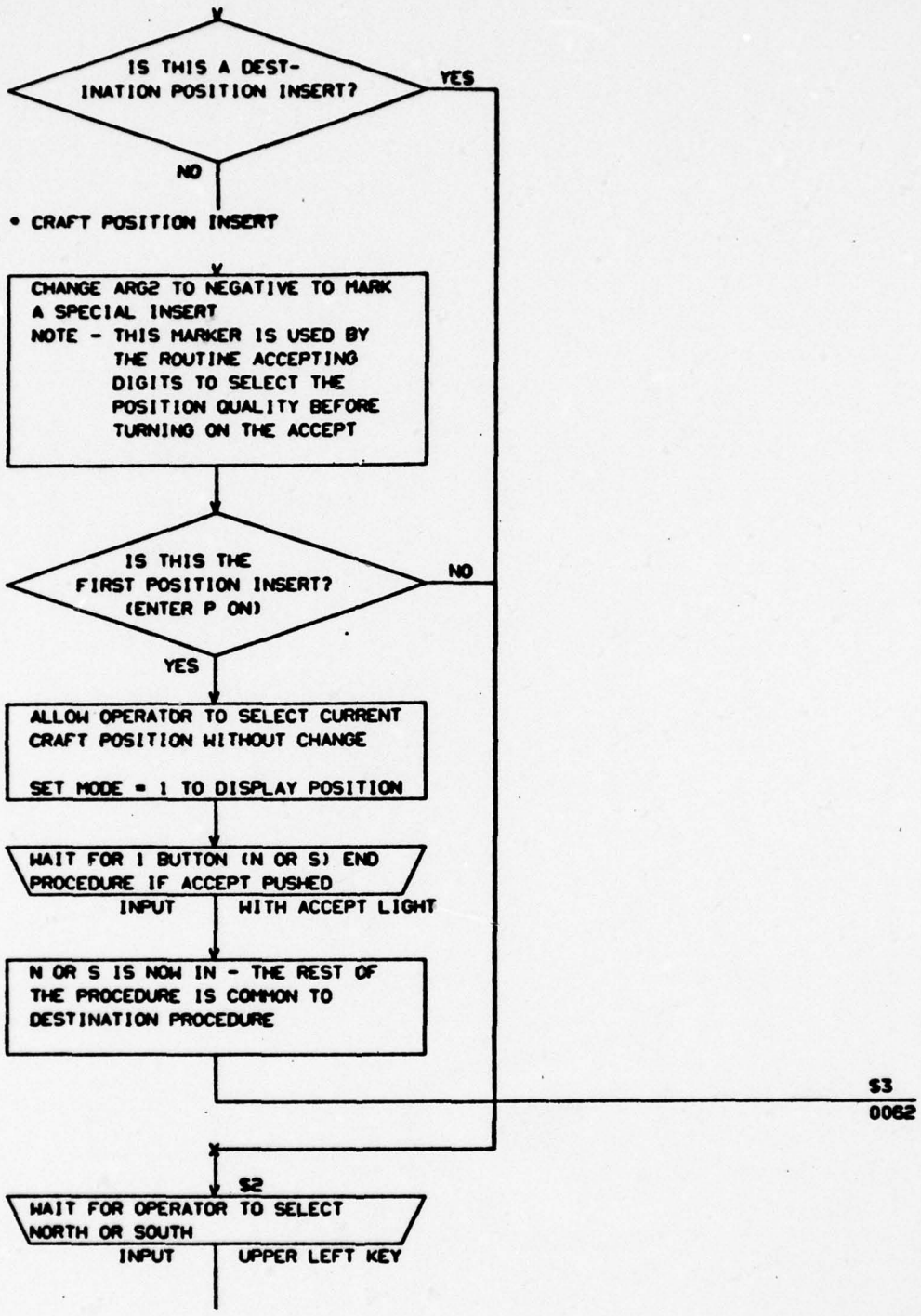

$4
TURN OFF THE ACCEPT LAMP AND DELETE IT FROM THE SWITCH MASK
SAVE MODE IN ACCEPT OLD MARKER THE MODE WILL BE ZERO UNLESS THE OPERATOR HAS IN A PROCEDURE WHERE THE OLD DATA HAS DISPLAYED ON THE PANEL (MODE = 1) AND IT HAS ACCEPTED WITHOUT CHANGE
SET INSERT MODE (2) THIS WILL CAUSE THE C/I PANEL NON OMEGA TASK ROUTINE TO PROCESS THE INSERTED DATA
$1
0058
• ENTER HERE FOR NCTR OR COH
NCT DISPLAY
TURN ON STATION LAMPS
$1
WAIT FOR ONE BUTTON - OPERATOR WILL SELECT A STATION
INPUT
UPPER LEFT KEY
SAVE LAMP BIT IN IMAGE12 FOR UPPER RIGHT KEY DISPLAY AT END OF PROCEDURE
SAVE BUTTON NO. IN ARG1 FOR USE BY DISPLAY ROUTINE
PROCEDURE COMPLETE
DISFINAL
0058

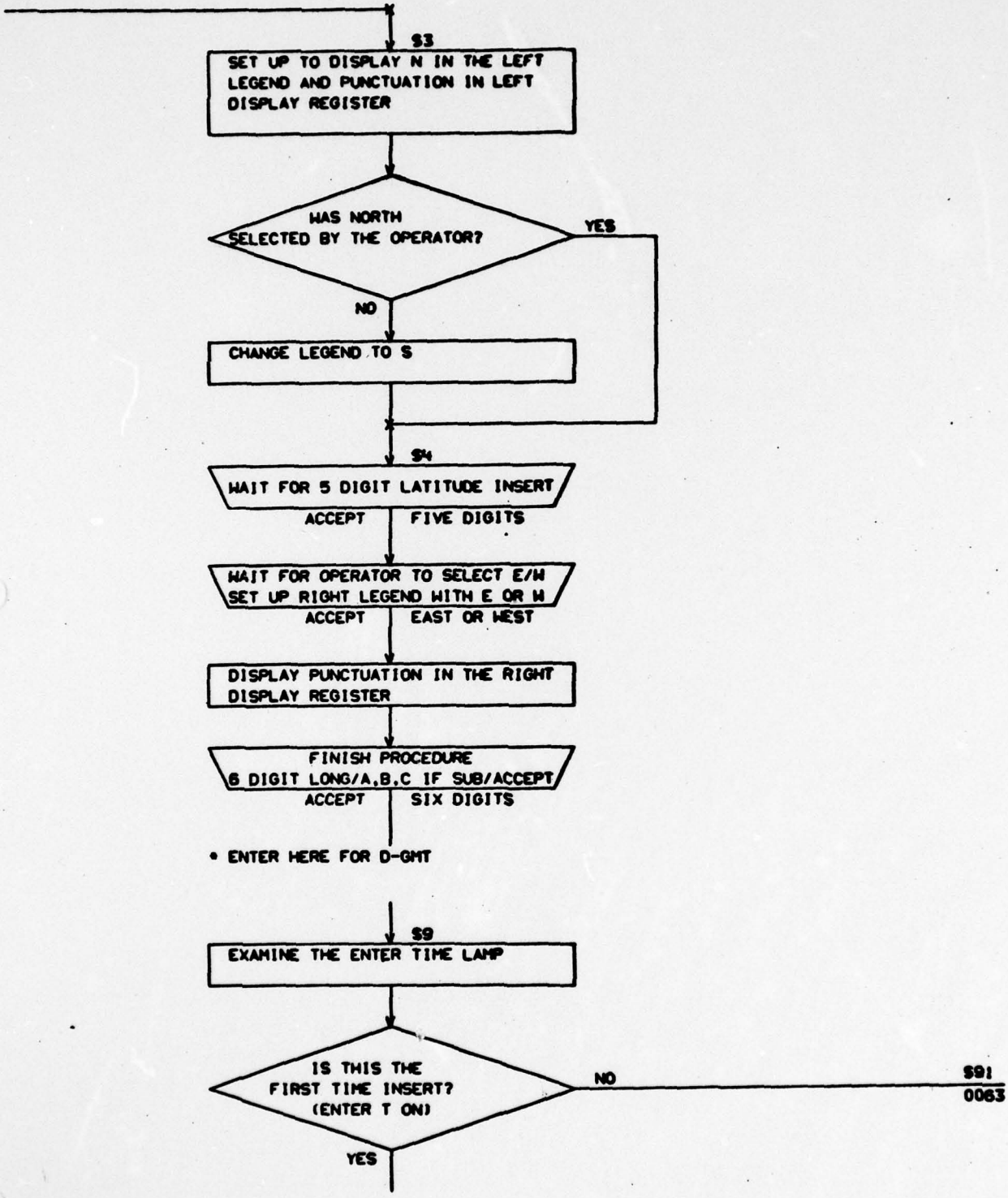
```
•                          INSERT PROCEDURES
•
• ENTER HERE WHEN THE ACCEPT/INSERT BUTTON IS DEPPRESSED.  ALL INSERT
• PROCEDURES ARE INITIATED AND CONTROLLED HERE.  IF THE ACCEPT LAMP IS
• ON THEN AN INSERT PROCEDURE IS COMPLETE OTHERWISE THE INSERT LAMP IS
• ON AND A PROCEDURE IS TO BE INITIATED.
•
```

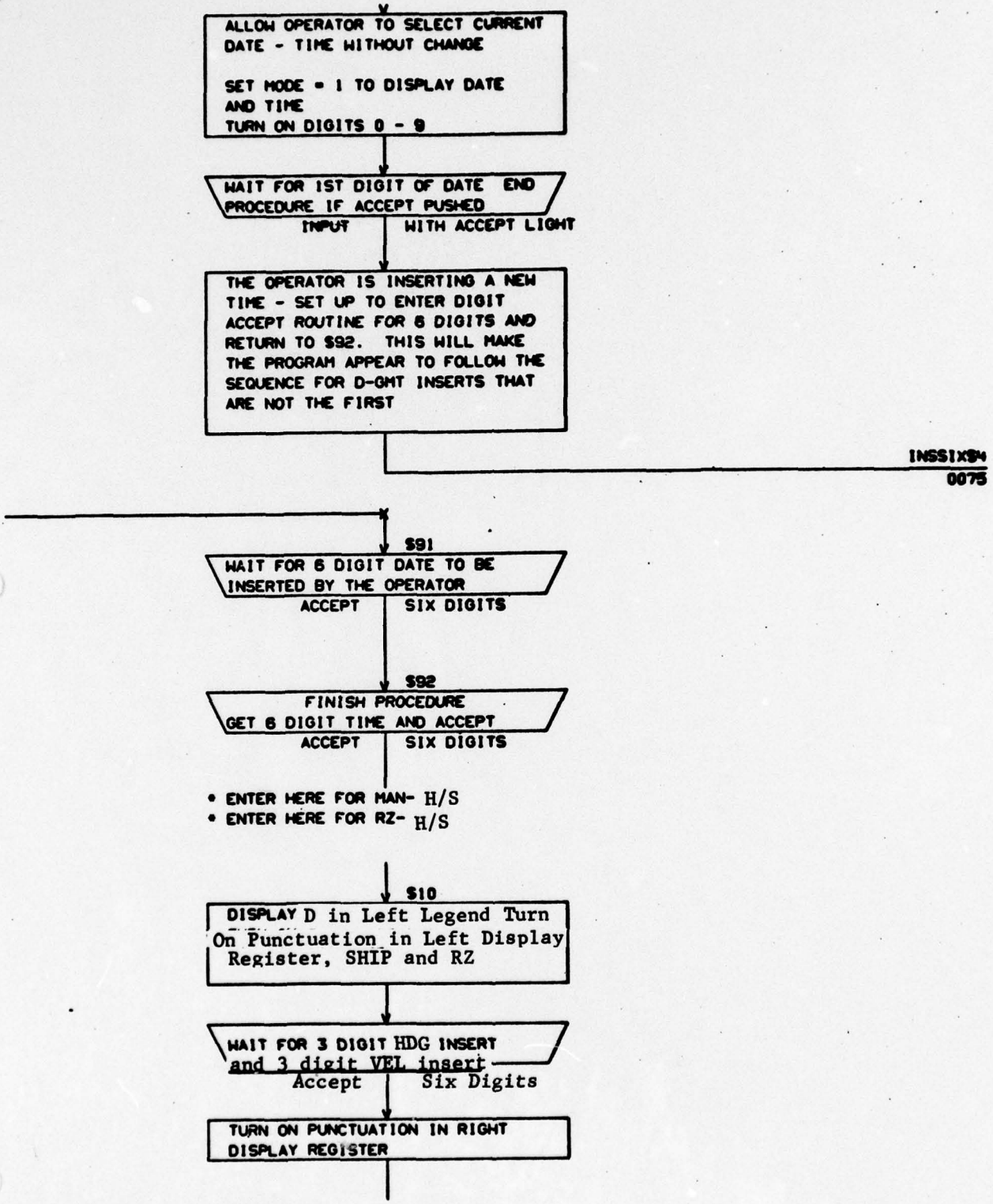


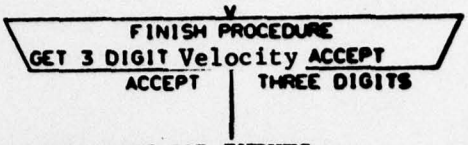

```
* 11 = POSITION ($1)
*  0 = INPUTS
*  5 = D-GMT
*  8 = MAN H/S
```


WAS THE POSITION INSERT PROCEDURE SELECTED
NO
$7
SEE TABLE $7
DT-GMT
INPUTS
MAN H/S
YES
• POSITION INSERT
$1
TURN ON THE DIGITS 0 - 9 TO SELECT A DESTINATION POSITION
IS THE ENTER TIME LAMP OFF?
NO
YES
ALLOW CRAFT POSITION INSERTS
TURN ON SUB LAMP
$19
WAIT FOR NEXT BUTTON - SAVE NO. IN ARG1 AND LAMP BIT IN IMAGE11
ACCEPT
ARGUMENT
• ENTER HERE FOR RZ POS
$21
TURN ON THE N AND S LAMPS FOR THE LATITUDE

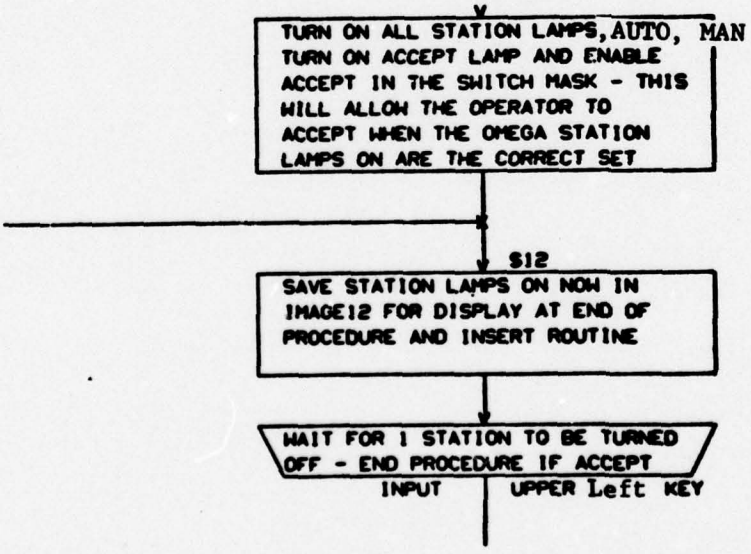

IS THIS A DEST-
INATION POSITION INSERT?
YES
NO
• CRAFT POSITION INSERT
CHANGE ARG2 TO NEGATIVE TO MARK
A SPECIAL INSERT
NOTE - THIS MARKER IS USED BY
THE ROUTINE ACCEPTING
DIGITS TO SELECT THE
POSITION QUALITY BEFORE
TURNING ON THE ACCEPT
IS THIS THE
FIRST POSITION INSERT?
(ENTER P ON)
NO
YES
ALLOW OPERATOR TO SELECT CURRENT
CRAFT POSITION WITHOUT CHANGE
SET MODE = 1 TO DISPLAY POSITION
WAIT FOR 1 BUTTON (N OR S) END
PROCEDURE IF ACCEPT PUSHED
INPUT
WITH ACCEPT LIGHT
N OR S IS NOW IN - THE REST OF
THE PROCEDURE IS COMMON TO
DESTINATION PROCEDURE
S3
0062
S2
WAIT FOR OPERATOR TO SELECT
NORTH OR SOUTH
INPUT
UPPER LEFT KEY

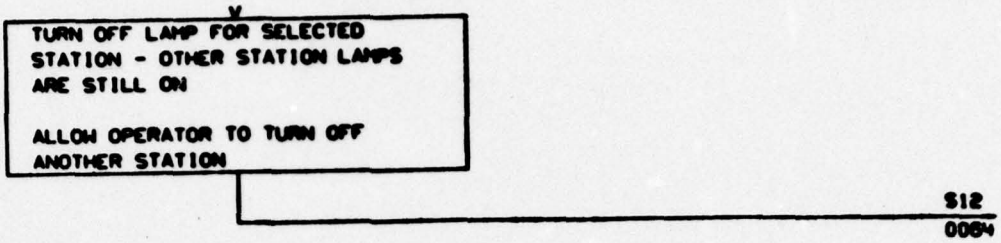

S3
SET UP TO DISPLAY N IN THE LEFT LEGEND AND PUNCTUATION IN LEFT DISPLAY REGISTER
HAS NORTH SELECTED BY THE OPERATOR?
YES
NO
CHANGE LEGEND TO S
S4
WAIT FOR 5 DIGIT LATITUDE INSERT
ACCEPT
FIVE DIGITS
WAIT FOR OPERATOR TO SELECT E/W SET UP RIGHT LEGEND WITH E OR W
ACCEPT
EAST OR WEST
DISPLAY PUNCTUATION IN THE RIGHT DISPLAY REGISTER
FINISH PROCEDURE
6 DIGIT LONG/A,B,C IF SUB/ACCEPT
ACCEPT
SIX DIGITS
• ENTER HERE FOR D-GMT
S9
EXAMINE THE ENTER TIME LAMP
IS THIS THE FIRST TIME INSERT? (ENTER T ON)
NO
S91
0063
YES


ALLOW OPERATOR TO SELECT CURRENT DATE - TIME WITHOUT CHANGE
SET MODE = 1 TO DISPLAY DATE AND TIME
TURN ON DIGITS 0 - 9
WAIT FOR 1ST DIGIT OF DATE END PROCEDURE IF ACCEPT PUSHED
INPUT
WITH ACCEPT LIGHT
THE OPERATOR IS INSERTING A NEW TIME - SET UP TO ENTER DIGIT ACCEPT ROUTINE FOR 6 DIGITS AND RETURN TO $92. THIS WILL MAKE THE PROGRAM APPEAR TO FOLLOW THE SEQUENCE FOR D-GMT INSERTS THAT ARE NOT THE FIRST
INSSIX$4
0075
$91
WAIT FOR 6 DIGIT DATE TO BE INSERTED BY THE OPERATOR
ACCEPT
SIX DIGITS
$92
FINISH PROCEDURE
GET 6 DIGIT TIME AND ACCEPT
ACCEPT
SIX DIGITS
• ENTER HERE FOR MAN- H/S
• ENTER HERE FOR RZ- H/S
$10
DISPLAY D in Left Legend Turn On Punctuation in Left Display Register, SHIP and RZ
WAIT FOR 3 DIGIT HDG INSERT and 3 digit VEL insert
Accept
Six Digits
TURN ON PUNCTUATION IN RIGHT DISPLAY REGISTER

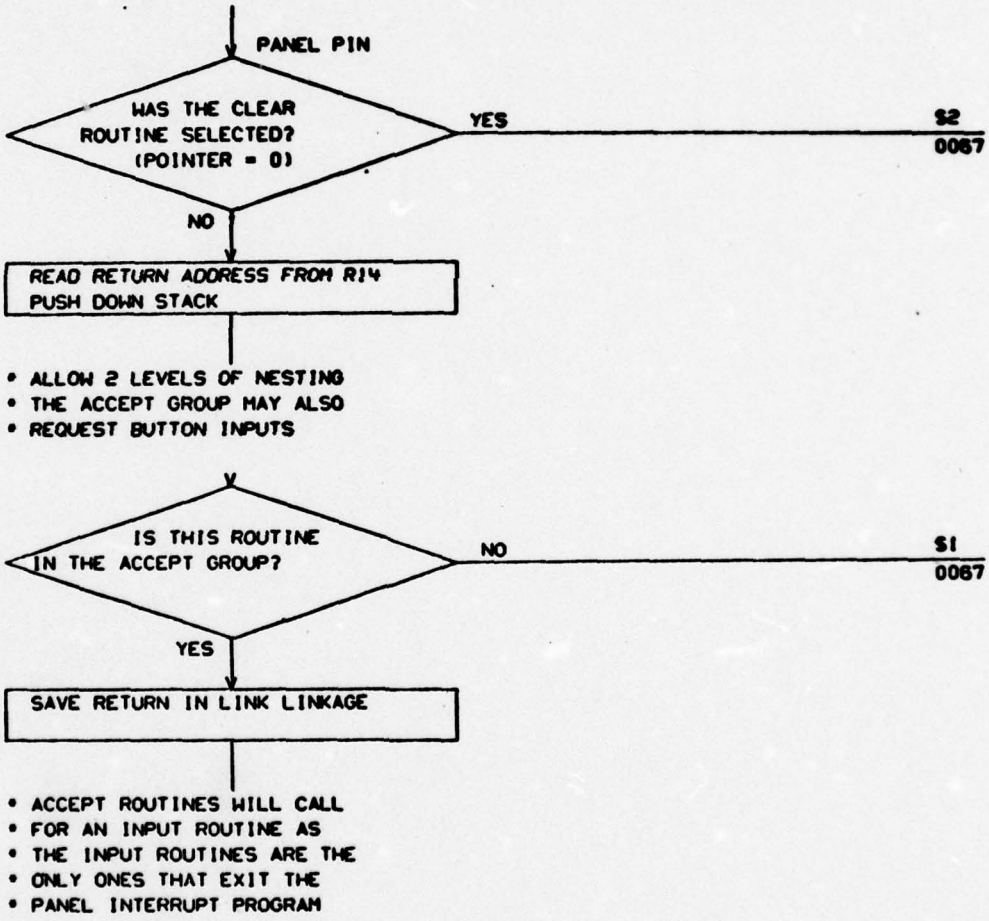


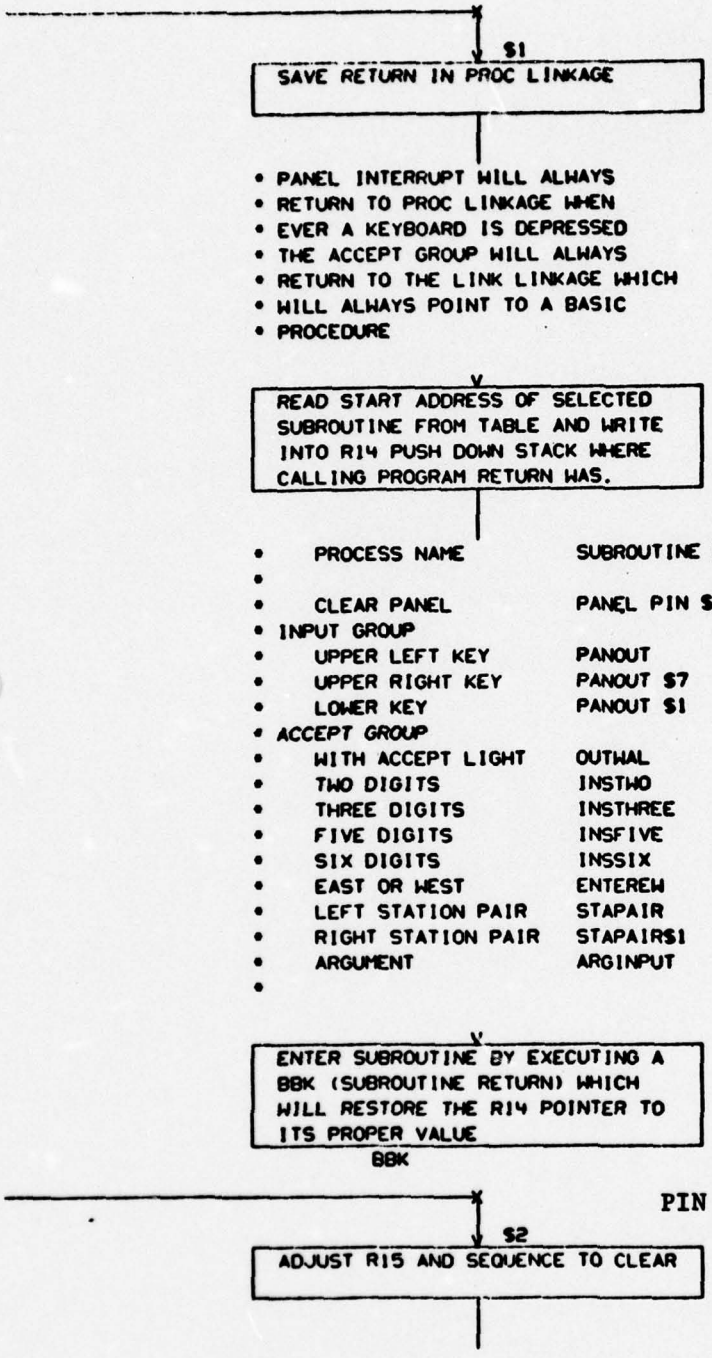
• ENTER HERE FOR INPUTS



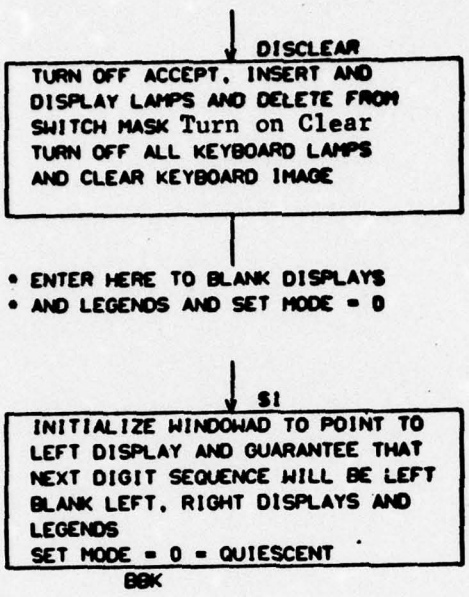

TURN OFF LAMP FOR SELECTED
STATION - OTHER STATION LAMPS
ARE STILL ON
ALLOW OPERATOR TO TURN OFF
ANOTHER STATION
S12
0064

```
•                    PANEL PIN SUBROUTINE
•
• THIS SUBROUTINE IS AN ENTRY POINT FOR ALL PANEL PROCEDURE SUBROUTINES.
• THESE ROUTINES ALL HAVE THE FEATURE OF NOT RETURNING TO THE CALLING
• PROCEDURE UNTIL THE OPERATOR DEPRESSES A BUTTON.  THE PANEL INPUT
• PROGRAM IS AN INTERRUPT PROGRAM THAT REQUIRES AN ORDERLY RETURN TO
• THE INTERRUPTED PROGRAM AND THEREFORE NORMAL SUBROUTINE ENTRIES CAN
• NOT BE USED IN THE PANEL INTERRUPT PROGRAM.  THIS SPECIAL ROUTINE
• REMOVES THE RETURN ADDRESS FROM THE R14 PUSHDOWN STACK AND SAVES IT
• IN SPECIAL LINKAGES FOR USE AFTER A BUTTON HAS BEEN DEPRESSED.  THIS
• ROUTINE THEN ENTERS THE SELECTED SUBROUTINE WHICH WILL TURN ON THE
• APPROPIATE LAMPS AND EXIT FROM THE PANEL INTERRUPT PROGRAM.  THE
• RETURN FROM THE SELECTED SUBROUTINE ACTUALLY OCCURS AFTER THE NEXT
• BUTTON HAS BEEN READ AND INTERPRETED AT WHICH TIME THE PANEL INTERRUPT
• PROGRAM WILL CONTINUE THE PROCEDURE BY USING THE LINKAGE FOR A RETURN.
• THE ARGUMENT CONSISTS OF A POINTER TO SELECT A SUBROUTINE FROM A TABLE
•
```

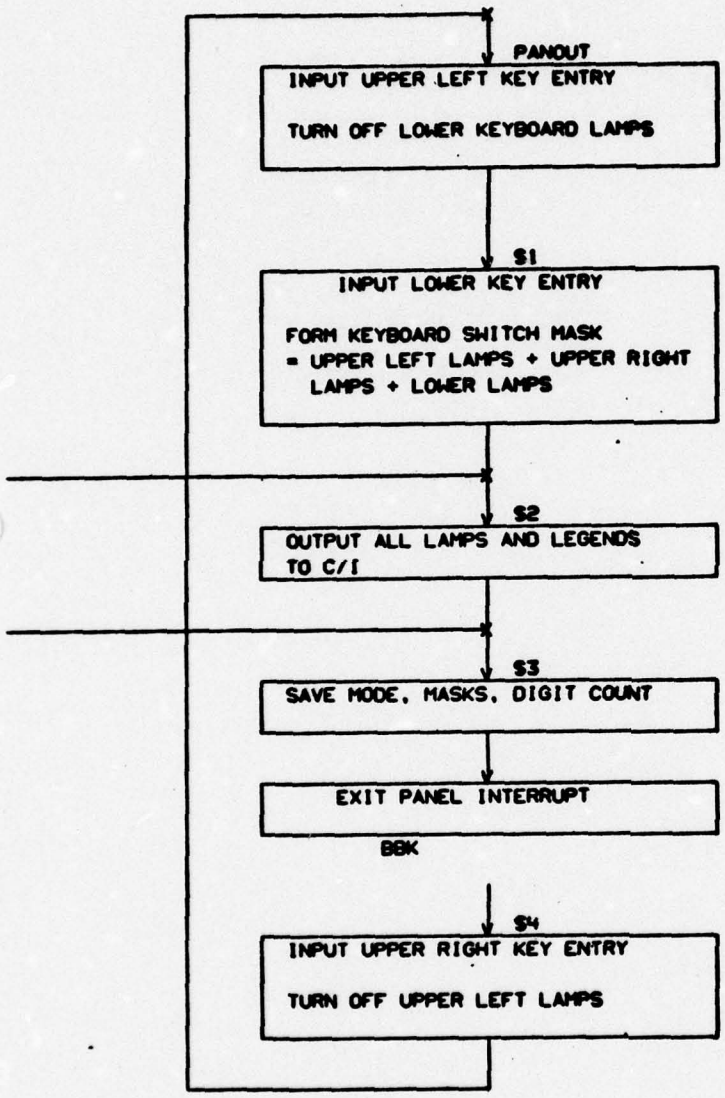



$1
SAVE RETURN IN PROC LINKAGE
• PANEL INTERRUPT WILL ALWAYS
• RETURN TO PROC LINKAGE WHEN
• EVER A KEYBOARD IS DEPRESSED
• THE ACCEPT GROUP WILL ALWAYS
• RETURN TO THE LINK LINKAGE WHICH
• WILL ALWAYS POINT TO A BASIC
• PROCEDURE
READ START ADDRESS OF SELECTED SUBROUTINE FROM TABLE AND WRITE INTO R14 PUSH DOWN STACK WHERE CALLING PROGRAM RETURN WAS.
• PROCESS NAME SUBROUTINE ENTRY
• CLEAR PANEL PANEL PIN $2
• INPUT GROUP
• UPPER LEFT KEY PANOUT
• UPPER RIGHT KEY PANOUT $7
• LOWER KEY PANOUT $1
• ACCEPT GROUP
• WITH ACCEPT LIGHT OUTWAL
• TWO DIGITS INSTWO
• THREE DIGITS INSTHREE
• FIVE DIGITS INSFIVE
• SIX DIGITS INSSIX
• EAST OR WEST ENTEREW
• LEFT STATION PAIR STAPAIR
• RIGHT STATION PAIR STAPAIR$1
• ARGUMENT ARGINPUT
ENTER SUBROUTINE BY EXECUTING A BBK (SUBROUTINE RETURN) WHICH WILL RESTORE THE R14 POINTER TO ITS PROPER VALUE
BBK
PIN ENTRY TO DISCLEAR
$2
ADJUST R15 AND SEQUENCE TO CLEAR

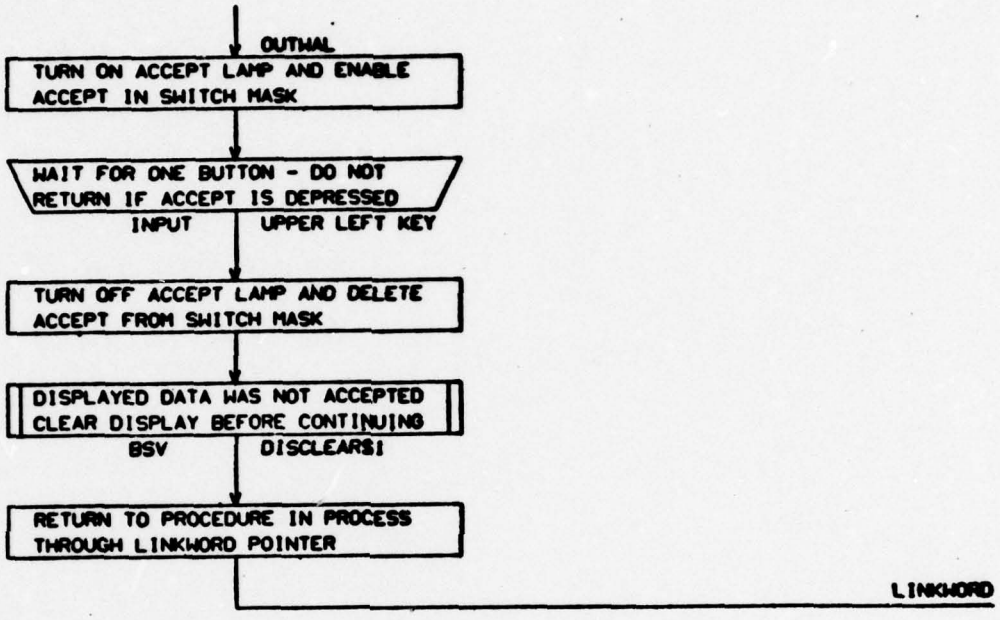
```
•
• CLEAR PANEL - PUT PROGRAM AND PANEL IN QUIESCENT STATE
•
```



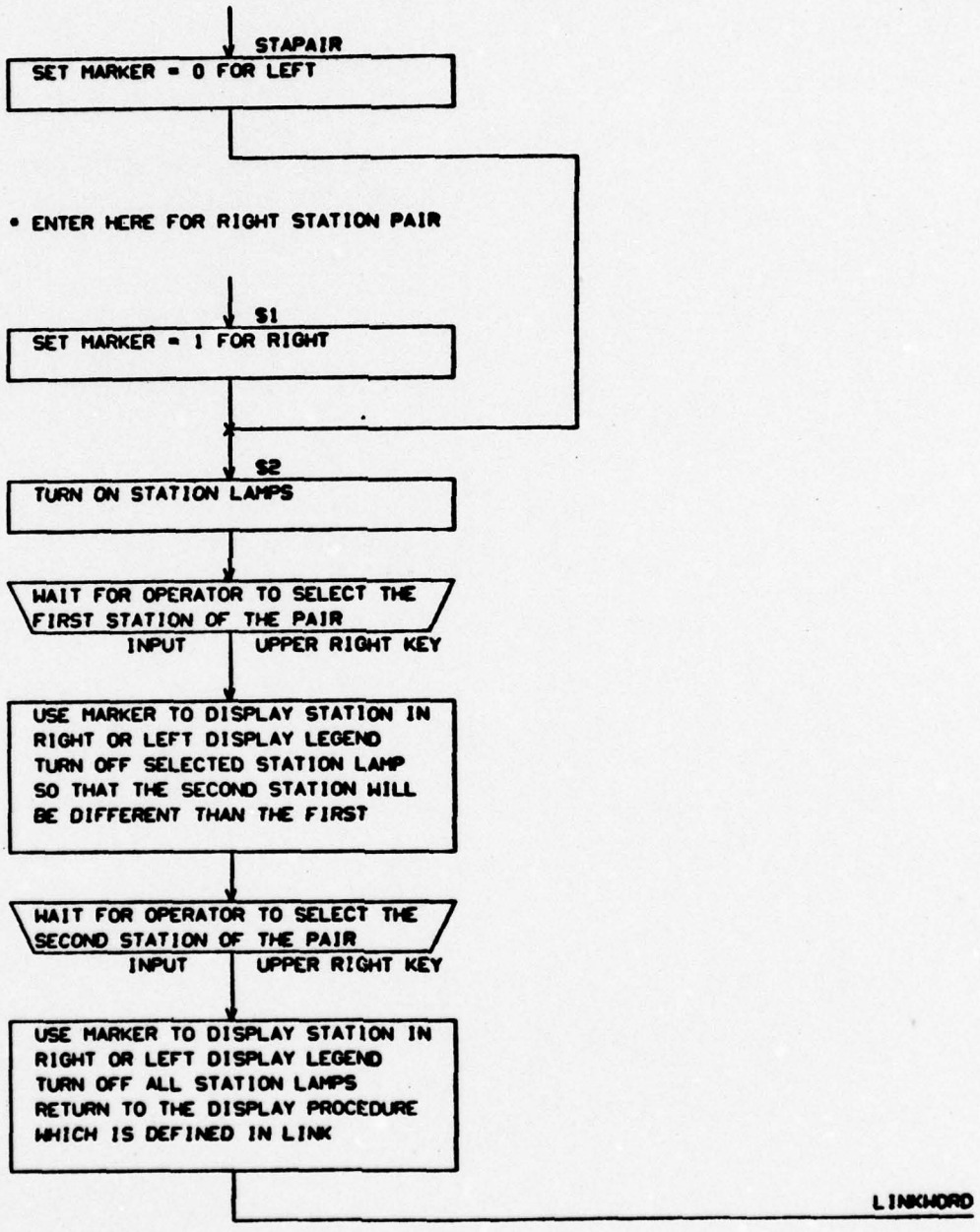
```
•                    INPUT KEYBOARD BUTTON
•
• THIS ROUTINE IS USED TO EXIT THE PANEL INTERRUPT ROUTINE WHILE A
• PROCEDURE IS IN PROCESS.  FIRST IT BUILDS THE KEYBOARD MASK FROM THE
• LAMPS TURNED ON BY THE PROCEDURE AND THEN IT OUTPUTS THE STATE OF ALL
• LAMPS AND LEGENDS TO THE C/I PANEL.
•
```



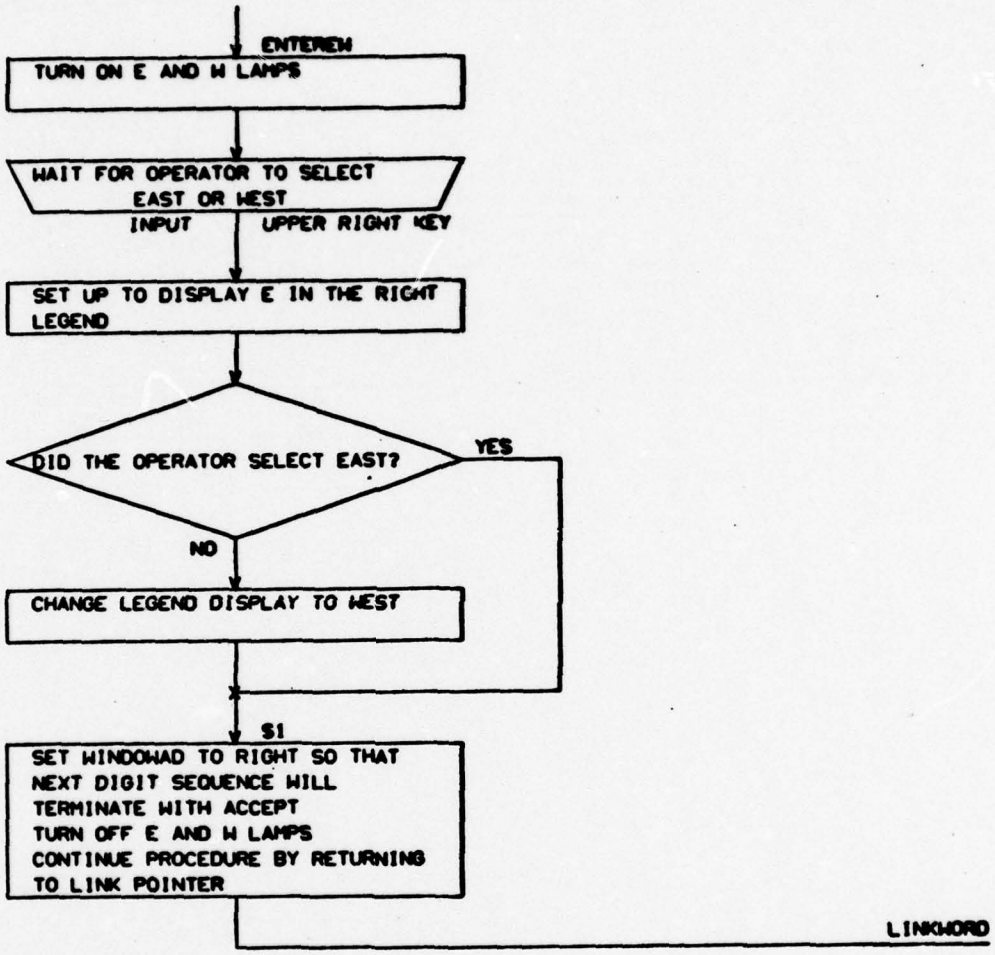
```
•                    WITH ACCEPT LAMP
•
• THIS ROUTINE WILL TURN ON THE ACCEPT LAMP IN ADDITION TO ANY OTHER
• LAMPS ALREADY ENABLED AND REQUEST ONE BUTTON INPUT.  IF THE NEXT
• BUTTON IS NOT ACCEPT IT WILL TURN OFF THE ACCEPT LAMP AND RETURN TO
• THE INPUT PROCEDURE
•
```



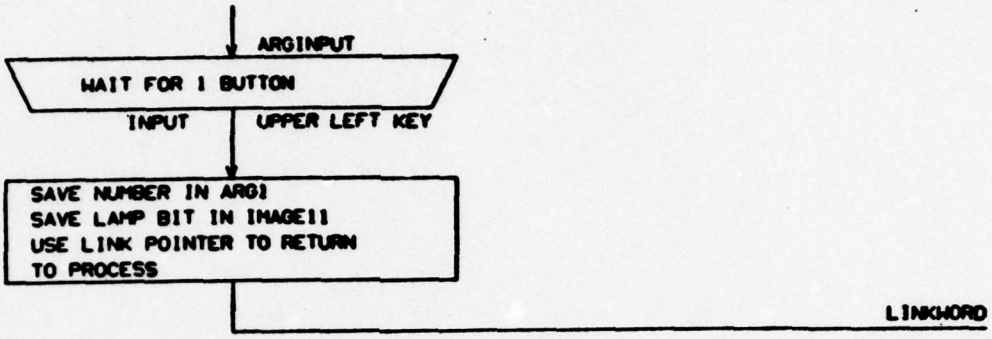
```
•                    STATION PAIR
•
• THIS ROUTINE IS USED BY THE LOP DISPLAY PROCEDURE TO ALLOW THE
• OPERATOR TO SELECT A PAIR OF STATIONS AND DISPLAY THE SELECTED PAIR
• IN THE LEGENDS
•
• ENTER HERE FOR LEFT STATION PAIR
```



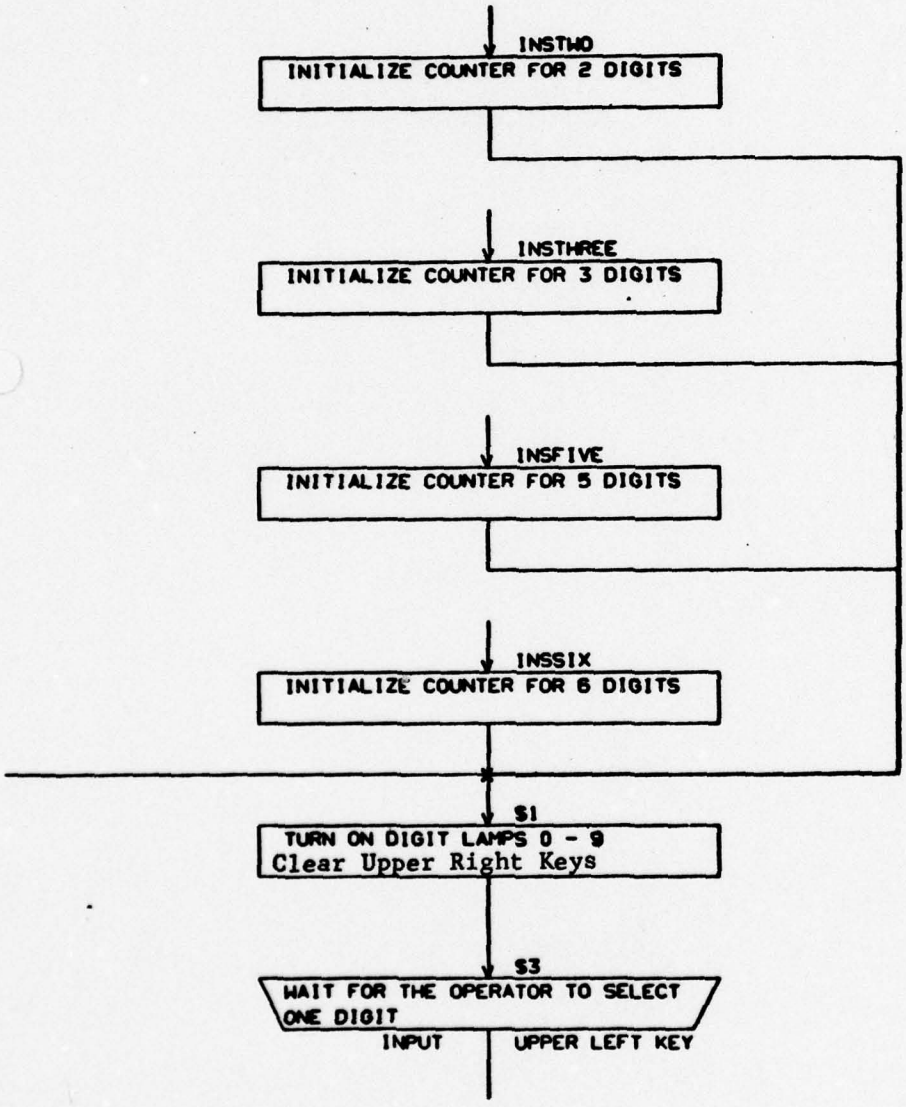
```
•                    INPUT EAST OR WEST
•
• THIS ROUTINE WILL ALLOW THE OPERATOR TO SELECT EAST OR WEST LONGITUDE
• AND DISPLAY THE E OR W IN THE RIGHT DISPLAY LEGEND
•
```

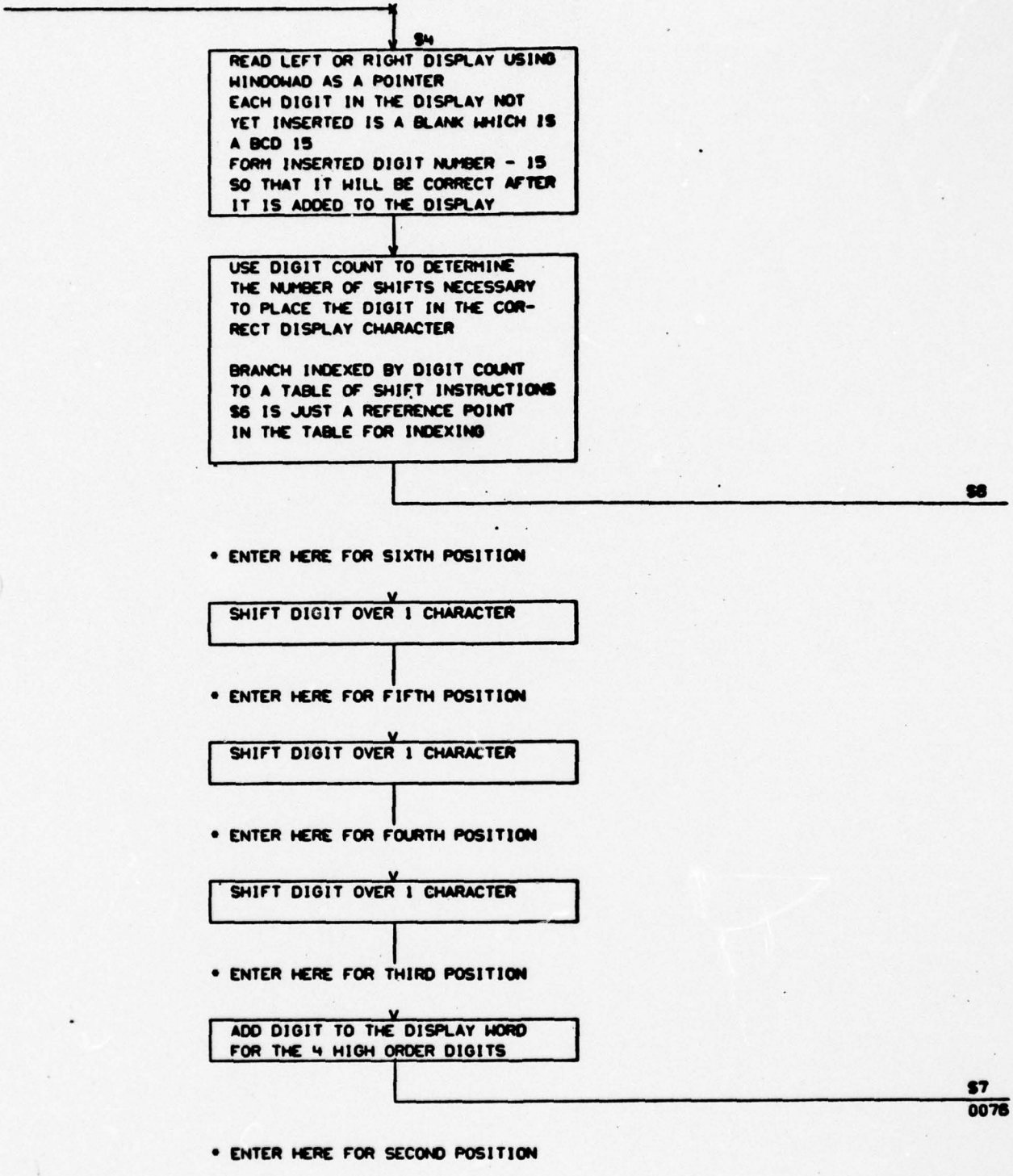


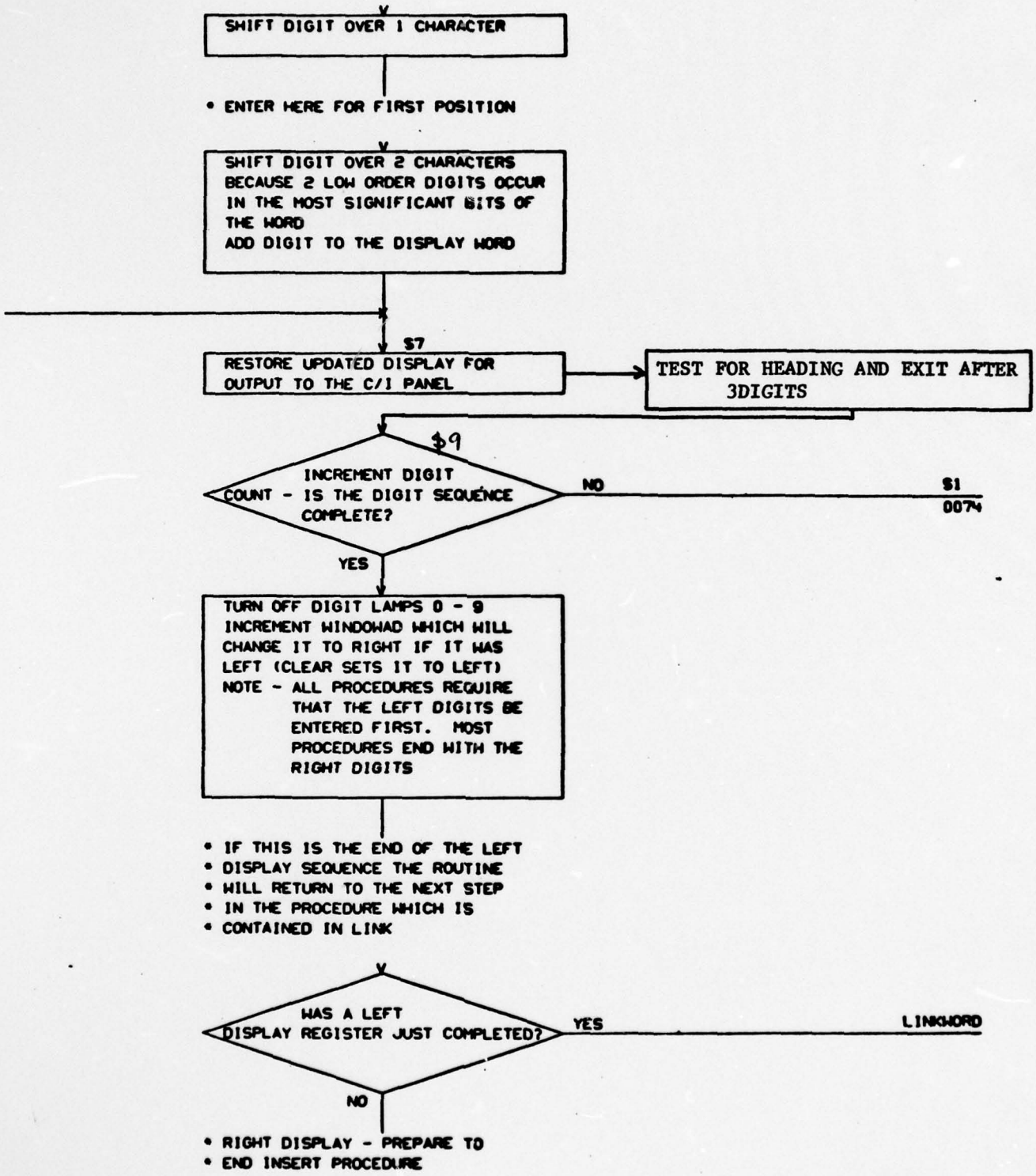
```
•                    ARGUMENT INPUT
•
• THIS ROUTINE WILL EXECUTE AN 'INPUT UPPER LEFT KEY' AND SAVE THE
• BUTTON NUMBER IN ARG1 AND THE LAMP BIT IN IMAGE11.  IT IS USED BY
• PROCEDURES THAT WANT TO PASS THE BUTTON NUMBER (UPPER LEFT) TO THE
• DISPLAY OR INSERT ROUTINES.
•
```

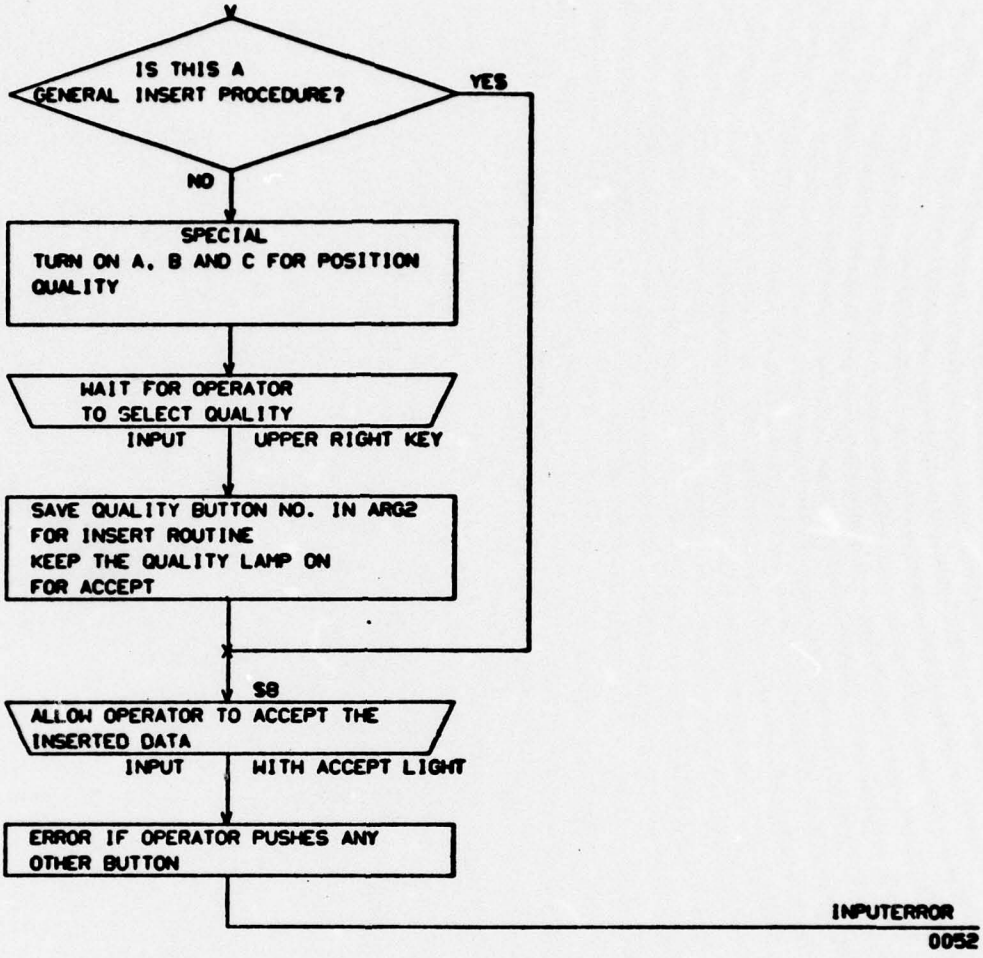


```
•                          DIGIT INPUT
•
• THIS ROUTINE PROCESSES STRINGS OF DIGITS AS REQUESTED BY THE CALLING
• PROGRAM.  IT HAS ENTRIES FOR STRINGS OF 2, 3, 5 AND 6 DIGITS.  ALL
• DIGITS ARE DISPLAYED IN THE APPROPIATE REGISTER AS INDICATED BY
• WINDOWAD.  IT IS ASSUMED THAT THE LAST DIGIT IN GOES INTO THE RIGHT
• MOST DIGIT OF THE DISPLAY AND ALL OTHERS ARE PLACED ACCORDINGLY.  IT
• HAS SPECIAL PROVISIONS TO INCREMENT THE WINDOWAD BY 2 AT THE END OF
• EACH SEQUENCE.  IT WILL LOOK FOR A SPECIAL INSERT AND REQUEST POSITION
• QUALITY DATA IF REQUIRED.  IF THE DISPLAY REGISTER IS THE RIGHT DIS-
• PLAY IT WILL TURN ON THE ACCEPT LAMP AT THE END OF THE SEQUENCE
•
```

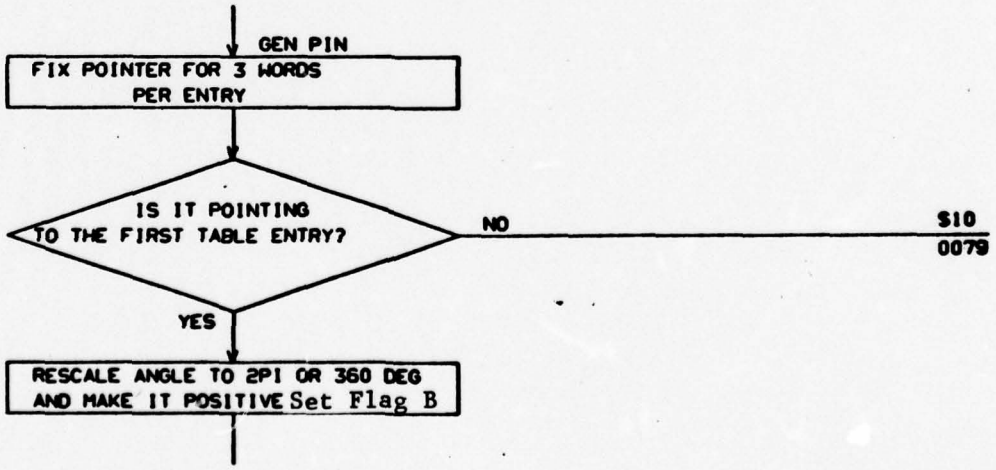


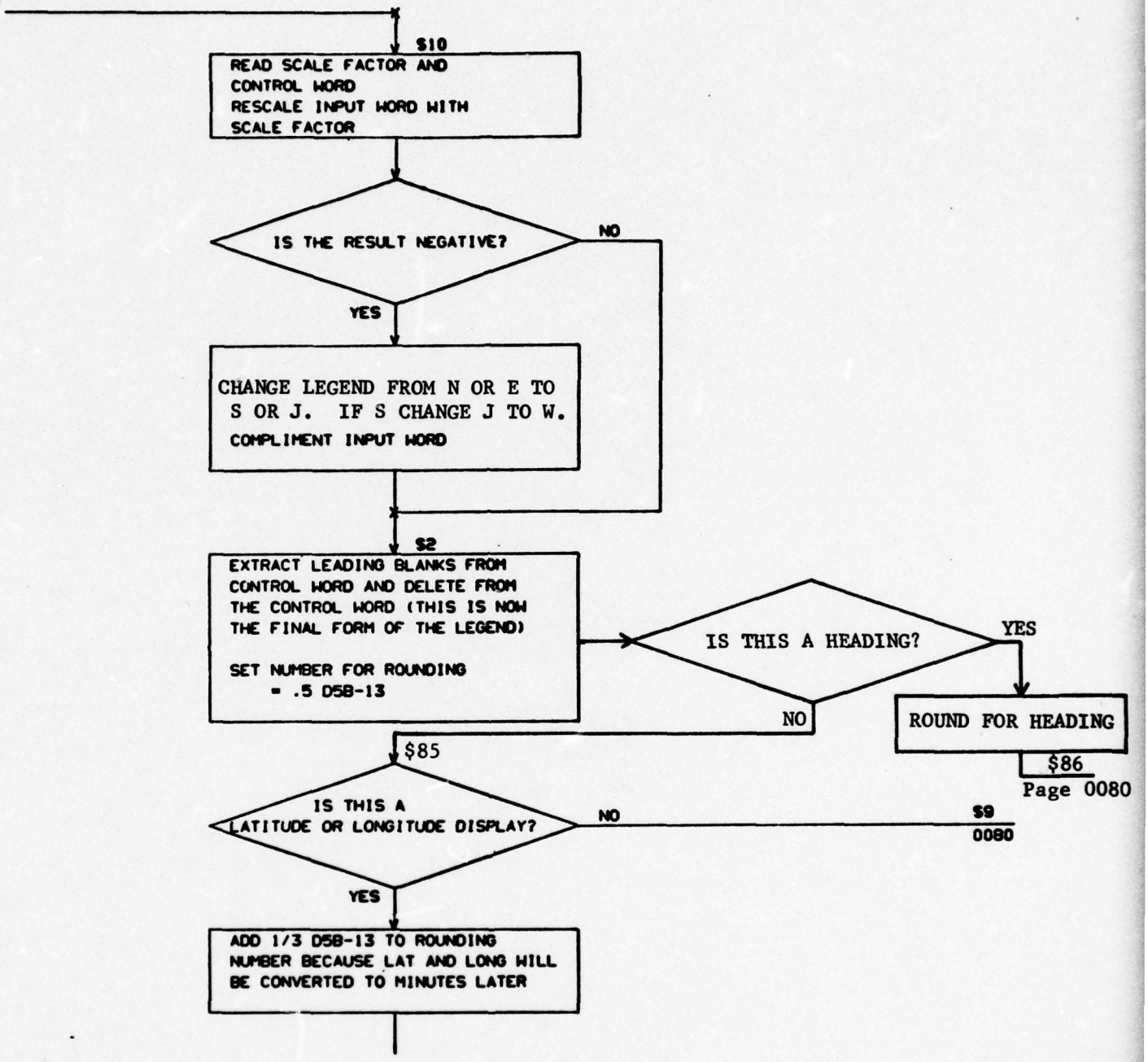

$4
READ LEFT OR RIGHT DISPLAY USING WINDOWAD AS A POINTER
EACH DIGIT IN THE DISPLAY NOT YET INSERTED IS A BLANK WHICH IS A BCD 15
FORM INSERTED DIGIT NUMBER - 15 SO THAT IT WILL BE CORRECT AFTER IT IS ADDED TO THE DISPLAY
USE DIGIT COUNT TO DETERMINE THE NUMBER OF SHIFTS NECESSARY TO PLACE THE DIGIT IN THE CORRECT DISPLAY CHARACTER
BRANCH INDEXED BY DIGIT COUNT TO A TABLE OF SHIFT INSTRUCTIONS
$6 IS JUST A REFERENCE POINT IN THE TABLE FOR INDEXING
$8
• ENTER HERE FOR SIXTH POSITION
SHIFT DIGIT OVER 1 CHARACTER
• ENTER HERE FOR FIFTH POSITION
SHIFT DIGIT OVER 1 CHARACTER
• ENTER HERE FOR FOURTH POSITION
SHIFT DIGIT OVER 1 CHARACTER
• ENTER HERE FOR THIRD POSITION
ADD DIGIT TO THE DISPLAY WORD FOR THE 4 HIGH ORDER DIGITS
$7
0076
• ENTER HERE FOR SECOND POSITION

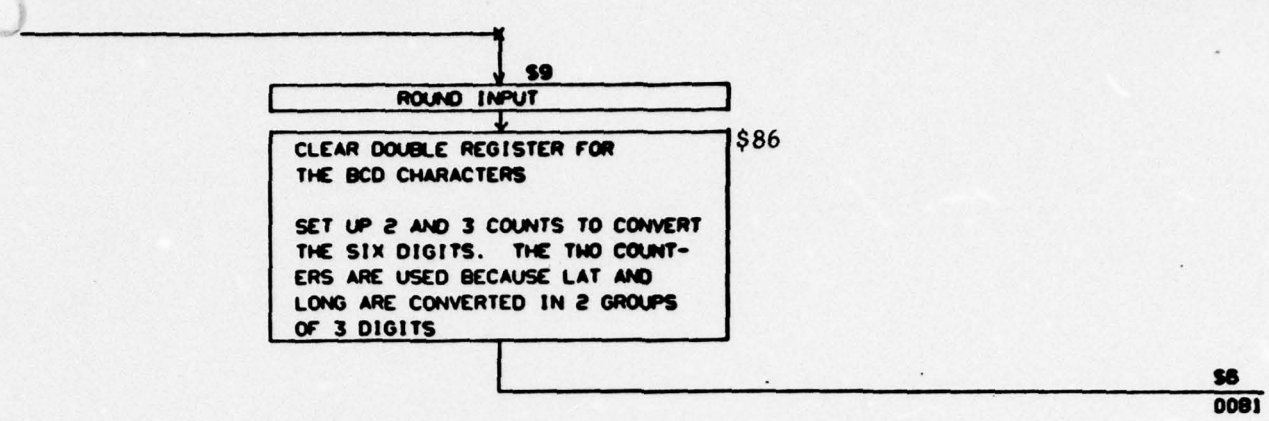

SHIFT DIGIT OVER 1 CHARACTER
• ENTER HERE FOR FIRST POSITION
SHIFT DIGIT OVER 2 CHARACTERS BECAUSE 2 LOW ORDER DIGITS OCCUR IN THE MOST SIGNIFICANT BITS OF THE WORD
ADD DIGIT TO THE DISPLAY WORD
$7
RESTORE UPDATED DISPLAY FOR OUTPUT TO THE C/I PANEL
TEST FOR HEADING AND EXIT AFTER 3DIGITS
$9
INCREMENT DIGIT COUNT - IS THE DIGIT SEQUENCE COMPLETE?
NO
$1
0074
YES
TURN OFF DIGIT LAMPS 0 - 9
INCREMENT WINDOWAD WHICH WILL CHANGE IT TO RIGHT IF IT WAS LEFT (CLEAR SETS IT TO LEFT)
NOTE - ALL PROCEDURES REQUIRE THAT THE LEFT DIGITS BE ENTERED FIRST. MOST PROCEDURES END WITH THE RIGHT DIGITS
• IF THIS IS THE END OF THE LEFT
• DISPLAY SEQUENCE THE ROUTINE
• WILL RETURN TO THE NEXT STEP
• IN THE PROCEDURE WHICH IS
• CONTAINED IN LINK
WAS A LEFT DISPLAY REGISTER JUST COMPLETED?
YES
LINKWORD
NO
• RIGHT DISPLAY - PREPARE TO
• END INSERT PROCEDURE


IS THIS A GENERAL INSERT PROCEDURE?
YES
NO
SPECIAL
TURN ON A, B AND C FOR POSITION QUALITY
WAIT FOR OPERATOR TO SELECT QUALITY
INPUT
UPPER RIGHT KEY
SAVE QUALITY BUTTON NO. IN ARG2 FOR INSERT ROUTINE
KEEP THE QUALITY LAMP ON FOR ACCEPT
S8
ALLOW OPERATOR TO ACCEPT THE INSERTED DATA
INPUT
WITH ACCEPT LIGHT
ERROR IF OPERATOR PUSHES ANY OTHER BUTTON
INPUTERROR
0052

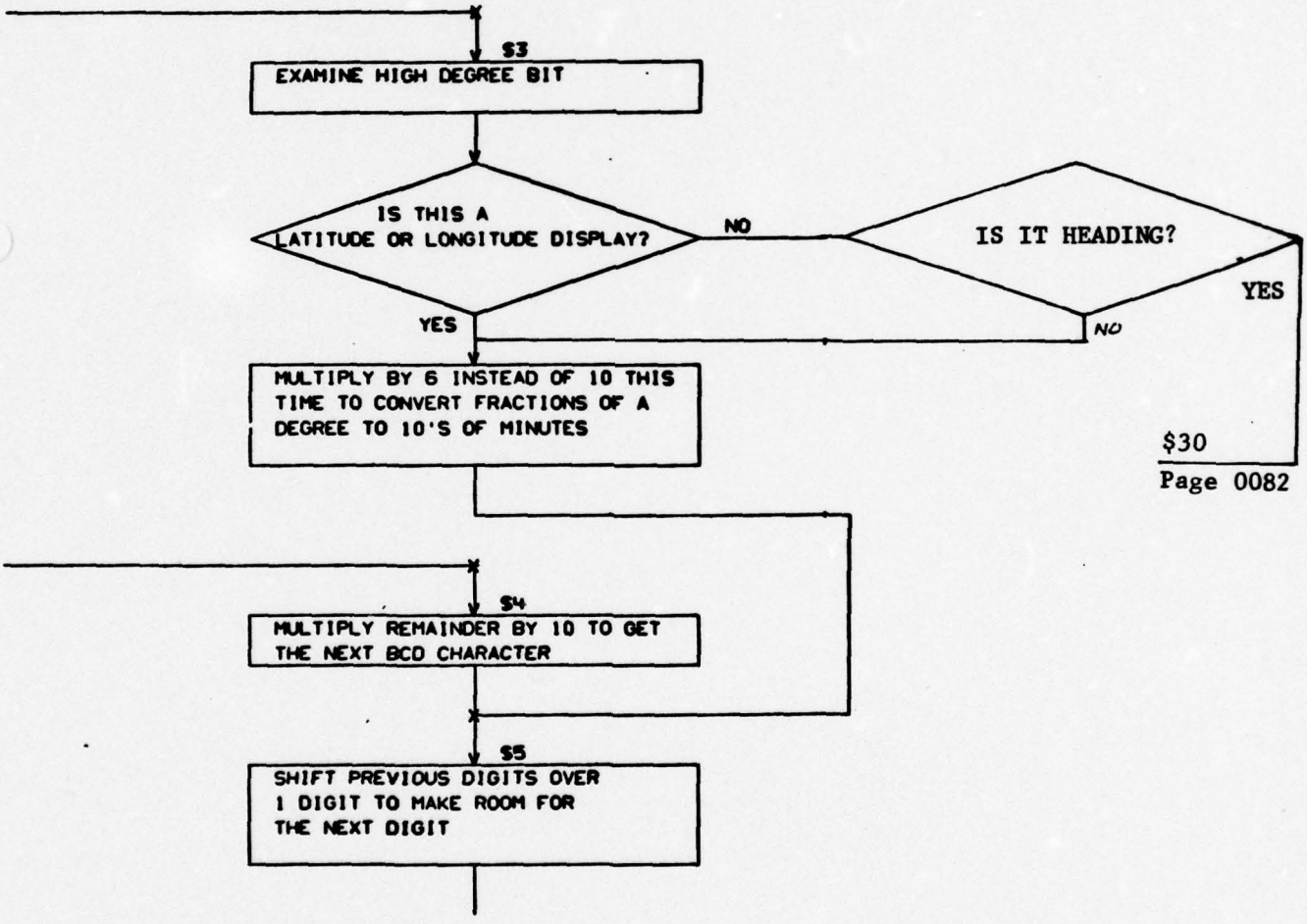
```
•                    DISPLAY CONVERSION ROUTINE
•
• THIS PIN ROUTINE WILL CONVERT DATA TO BCD FOR DISPLAY AND SET UP THE
• LEGEND.  THE INPUT CONSISTS OF A 32 BIT WORD TO BE DISPLAYED AND A
• POINTER TO A CONVERSION TABLE.  EACH ENTRY IN THE TABLE CONTAINS A 32
• BIT SCALE FACTOR AND A 16 BIT CONTROL WORD.  EACH INPUT WORD WILL BE
• MULTIPLIED BE THE SCALE FACTOR BEFORE CONVERSION TO BCD.  THE SCALE
• FACTOR SHOULD PUT THE INPUT WORD INTO THE UNITS OF THE LOWEST DIGIT OF
• THE DISPLAY (VELOCTY WOULD BE IN UNITS OF KNOTS) SCALED D+3 B+3.
• THIS ROUTINE WILL THEN CONVERT THE NUMBER TO 6 BCD DIGITS WITH THE
• LAST DIGIT APPEARING IN THE LOWEST DIGIT OF THE DISPLAY.
•
• THE 8 MSB'S OF THE CONTROL WORD ARE TRANSFERED DIRECTLY TO THE UPPER 8
• BITS OF THE LEGEND TO TURN ON THE PUNCTUATION AND/OR L, R, W, E FOR
• THE RIGHT DISPLAY AND KTS, NMI, S, N FOR THE LEFT DISPLAY.  IF THE
• SCALED INPUT WORD IS NEGATIVE BITS 9 TO 12 ARE ADDED TO THE LEGEND.
• THIS HAS THE EFFECT OF CHANGING N TO S, E TO W OR R TO L.  THE FOUR
• LSB'S OF THE CONTROL WORD DEFINE THE NUMBER OF LEADING BLANKS FOR A
• DISPLAY.  ALL ZERO'S IN THE FIRST N CHARACTERS ARE CHANGED TO BLANKS
•
• WHENEVER THE POINTER POINTS TO THE FIRST ENTRY IN THE CONVERSION TABLE
• (0) THE INPUT IS SHIFTED RIGHT ONE BIT WITHOUT SIGN SPREAD.  THIS IS
• USED FOR THE CONVERSION OF ANGLES WITH A RANGE OF +180 TO -180 TO
• ANGLES BETWEEN 0 AND 360.
•
• SPECIAL HANDLING OF LATITUDE AND LONGITUDE HAS BEEN PROVIDED BECAUSE
• THEY ARE DISPLAYED IN UNITS OF DEGREES AND MINUTES.  THE PUNCTUATION
• BIT IN THE CONTROL WORD THAT TURNS ON THE HIGH ORDER DEGREE LAMP IS
• USED AS A MARKER SIGNIFYING LAT OR LONG.  THE SCALE FACTOR MUST CON-
• VERT THEM TO DEGRESS SCALED D2B3.
•
• THE OUTPUT IS ALL SET UP FOR THE MAIN DISPLAY ROUTINE TO OUTPUT TO THE
• C/I PANEL.  EACH ENTRY SETS UP THE DISPLAY FOR EITHER THE LEFT OR THE
• RIGHT SIDE OF THE PANEL.  THE FIRST ENTRY IS THE RIGHT SIDE AND THE
• SECOND ENTRY SETS UP THE LEFT SIDE UNLESS THE CALLING PROGRAM SETS UP
• ONE OF THE DISPLAYS SEPARATELY
•
```

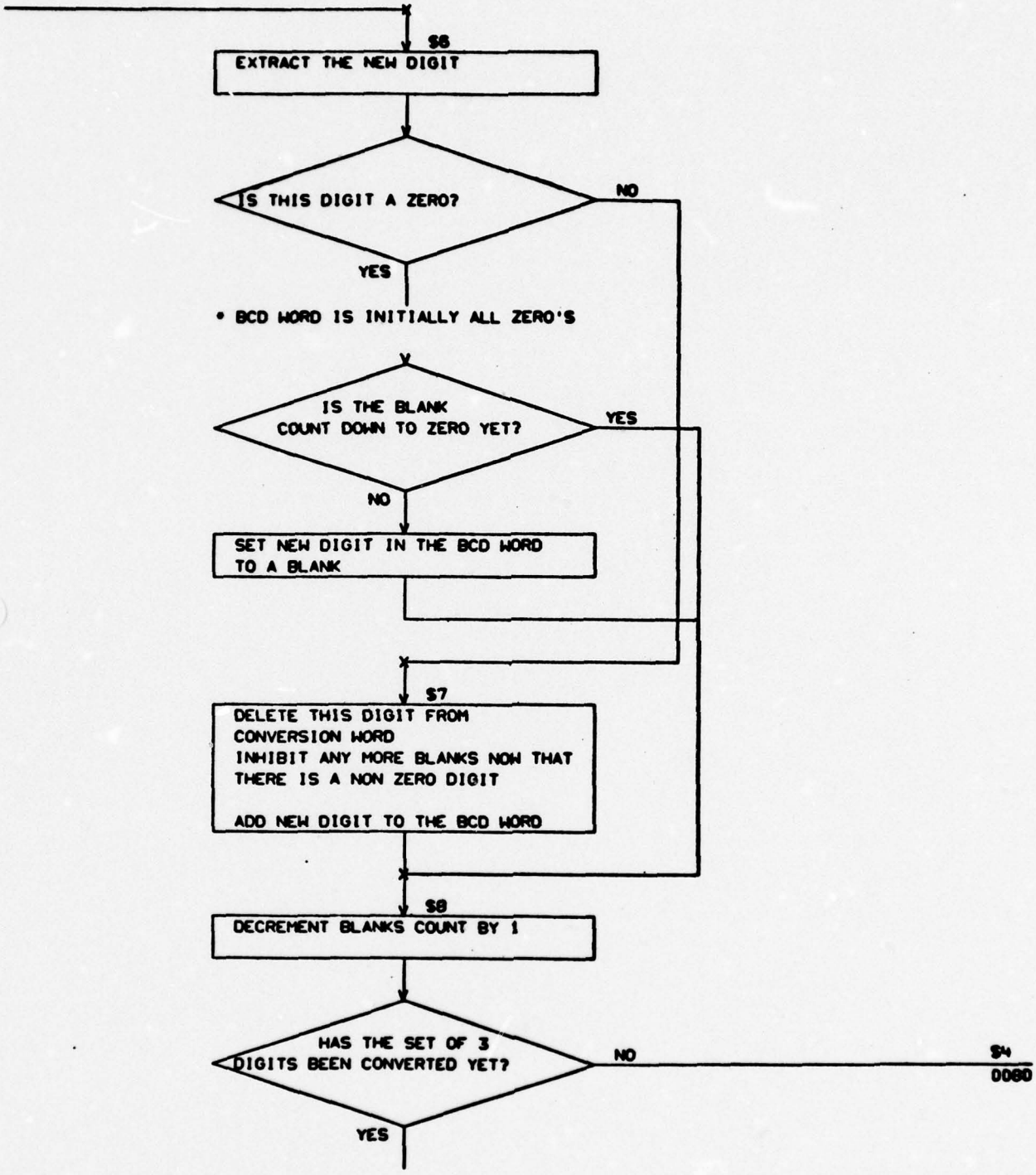


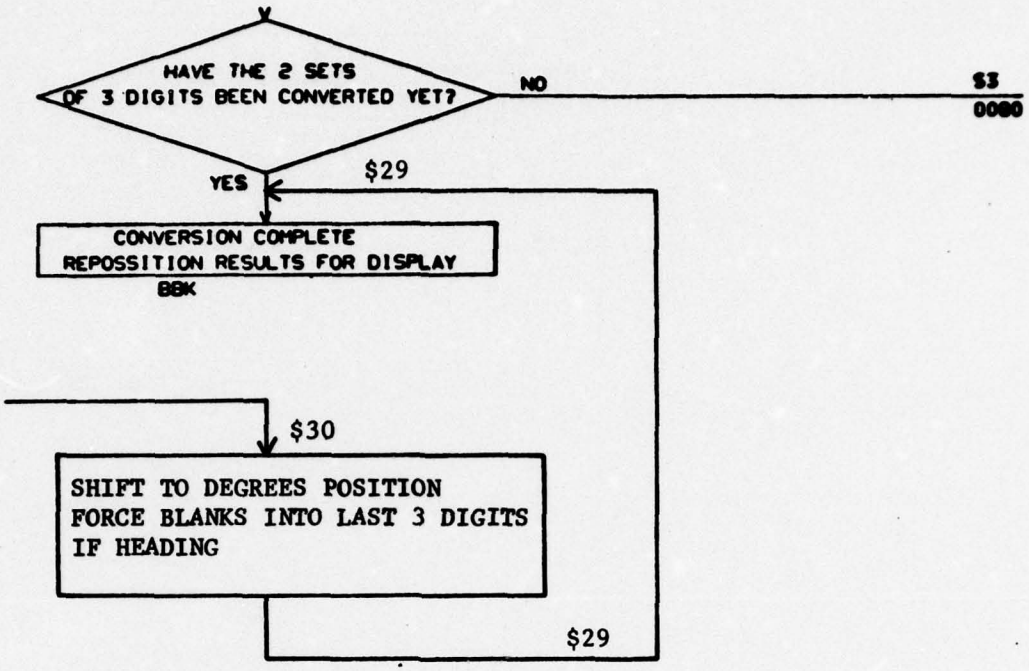

$10
READ SCALE FACTOR AND CONTROL WORD
RESCALE INPUT WORD WITH SCALE FACTOR
IS THE RESULT NEGATIVE?
NO
YES
CHANGE LEGEND FROM N OR E TO S OR J. IF S CHANGE J TO W.
COMPLIMENT INPUT WORD
$2
EXTRACT LEADING BLANKS FROM CONTROL WORD AND DELETE FROM THE CONTROL WORD (THIS IS NOW THE FINAL FORM OF THE LEGEND)
SET NUMBER FOR ROUNDING = .5 D5B-13
IS THIS A HEADING?
YES
NO
ROUND FOR HEADING
$86
Page 0080
$85
IS THIS A LATITUDE OR LONGITUDE DISPLAY?
NO
$9
0080
YES
ADD 1/3 D5B-13 TO ROUNDING NUMBER BECAUSE LAT AND LONG WILL BE CONVERTED TO MINUTES LATER



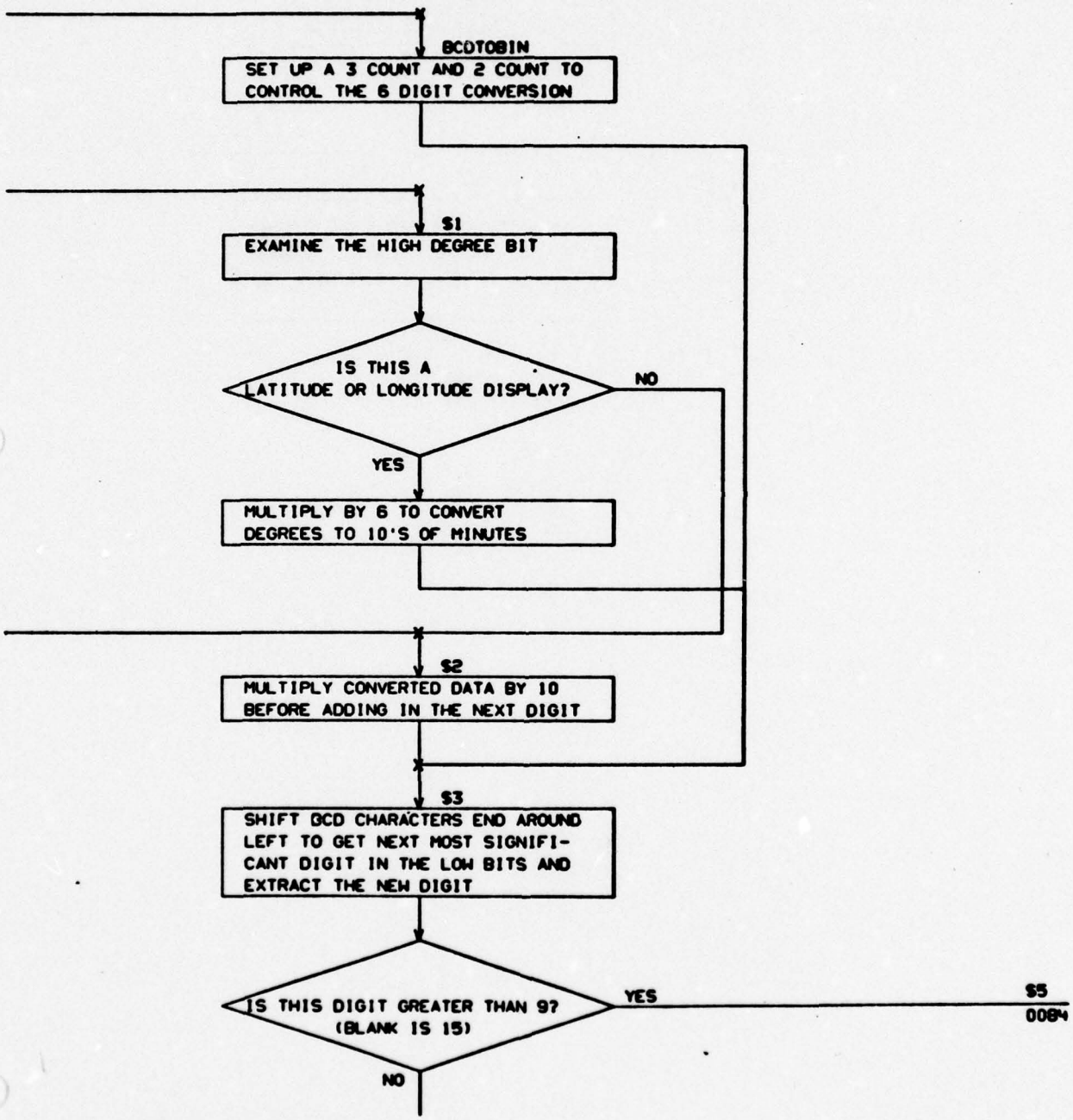
- THE ENTRY TO THE CONVERSION
- LOOP IS AT $8 PAGE 81.

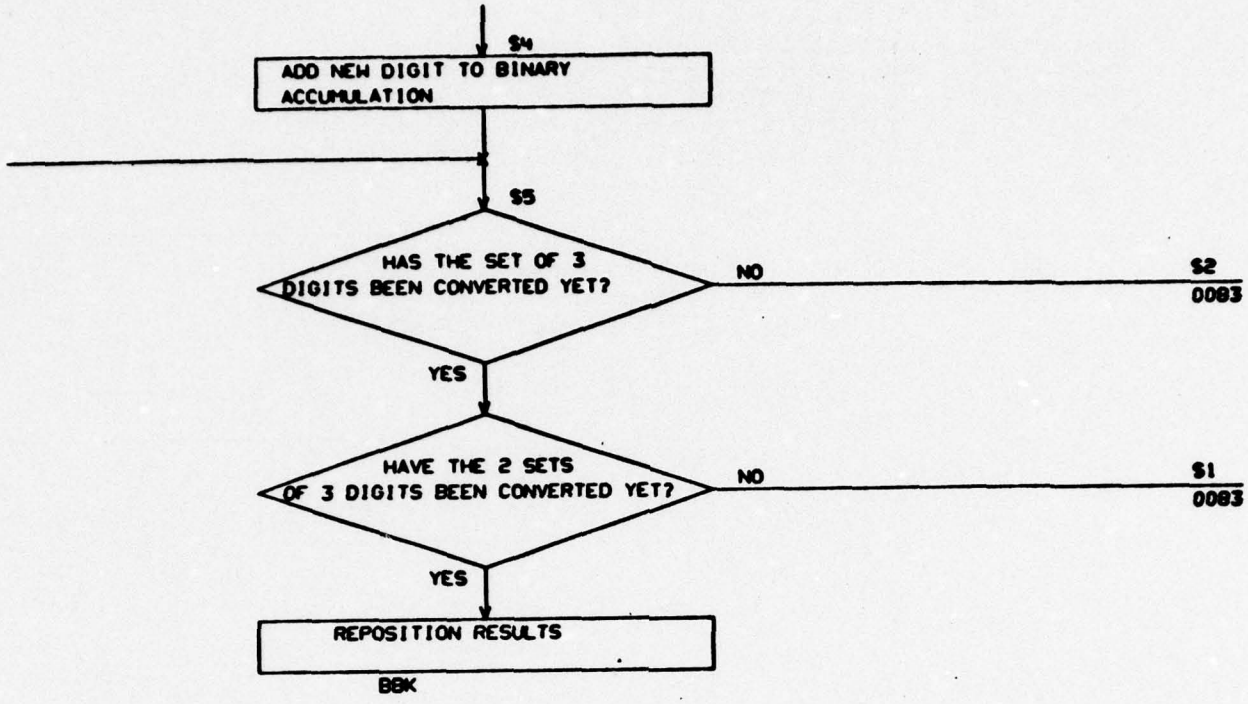



$6
EXTRACT THE NEW DIGIT
IS THIS DIGIT A ZERO?
NO
YES
• BCD WORD IS INITIALLY ALL ZERO'S
IS THE BLANK COUNT DOWN TO ZERO YET?
YES
NO
SET NEW DIGIT IN THE BCD WORD TO A BLANK
$7
DELETE THIS DIGIT FROM CONVERSION WORD
INHIBIT ANY MORE BLANKS NOW THAT THERE IS A NON ZERO DIGIT
ADD NEW DIGIT TO THE BCD WORD
$8
DECREMENT BLANKS COUNT BY 1
HAS THE SET OF 3 DIGITS BEEN CONVERTED YET?
NO
$4
0080
YES

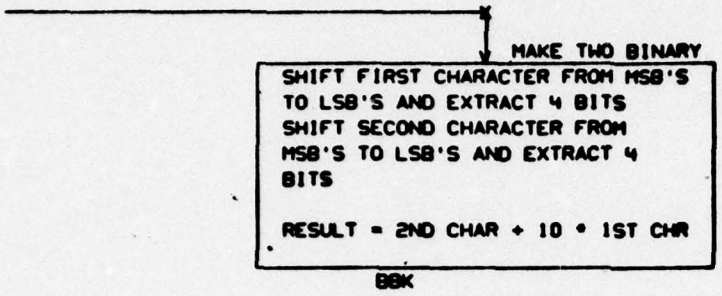

HAVE THE 2 SETS
OF 3 DIGITS BEEN CONVERTED YET?
NO
$3
0080
YES
$29
CONVERSION COMPLETE
REPOSSITION RESULTS FOR DISPLAY
BBK
$30
SHIFT TO DEGREES POSITION
FORCE BLANKS INTO LAST 3 DIGITS
IF HEADING
$29

```
•
•                    BCD TO BINARY
•
• THIS ROUTINE WILL CONVERT THE 6 CHARACTER DISPLAY IMAGE TO BINARY
• WITH THE LSB OF THE BINARY WORD EQUAL TO 1 COUNT IN THE LSD OF THE
• DISPLAY.  THE BIT IN THE LEGEND THAT TURNS ON THE HIGH ORDER DEGREE
• LAMP ON THE DISPLAY IS USED AS A MARKER TO SIGNIFY A LATITUDE OR LONG-
• ITUDE CONVERSION.
•
```

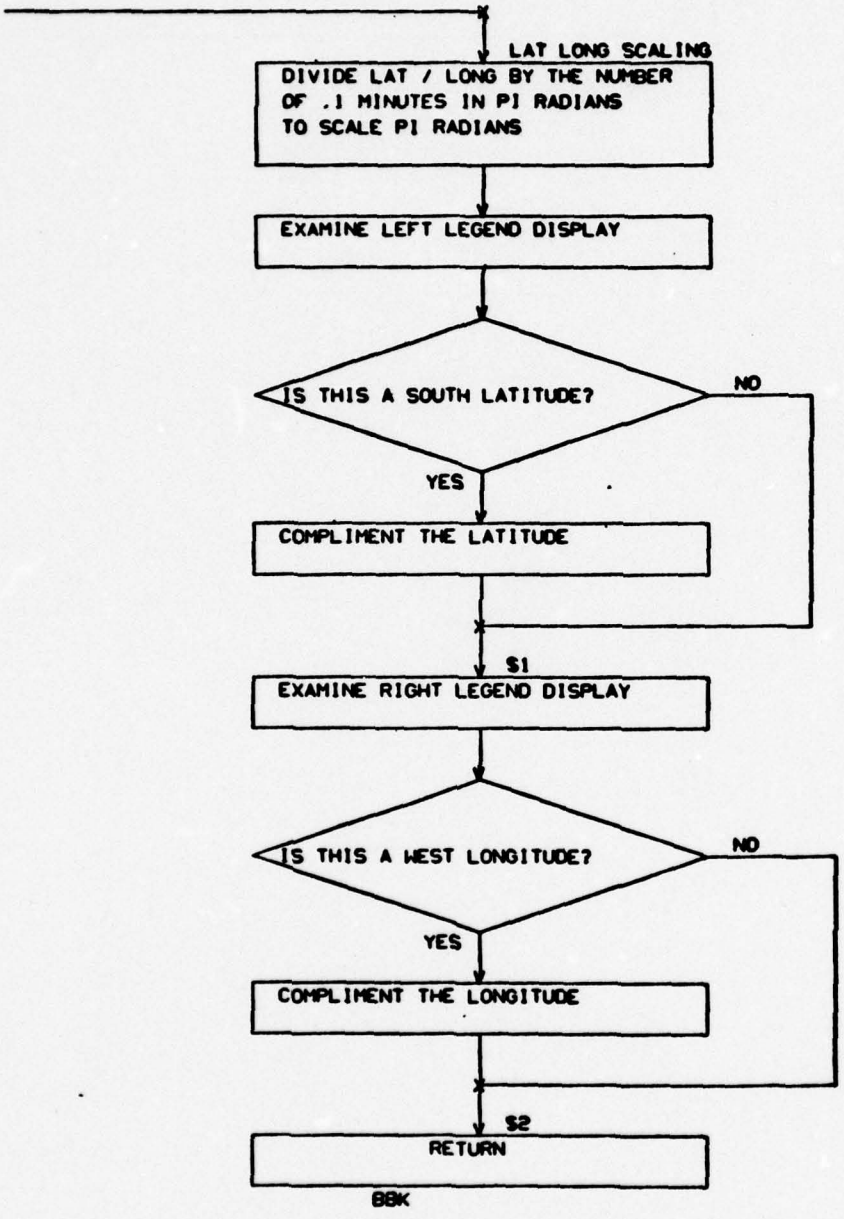



$4
ADD NEW DIGIT TO BINARY ACCUMULATION
$5
HAS THE SET OF 3 DIGITS BEEN CONVERTED YET?
NO
$2
0083
YES
HAVE THE 2 SETS OF 3 DIGITS BEEN CONVERTED YET?
NO
$1
0083
YES
REPOSITION RESULTS
BBK

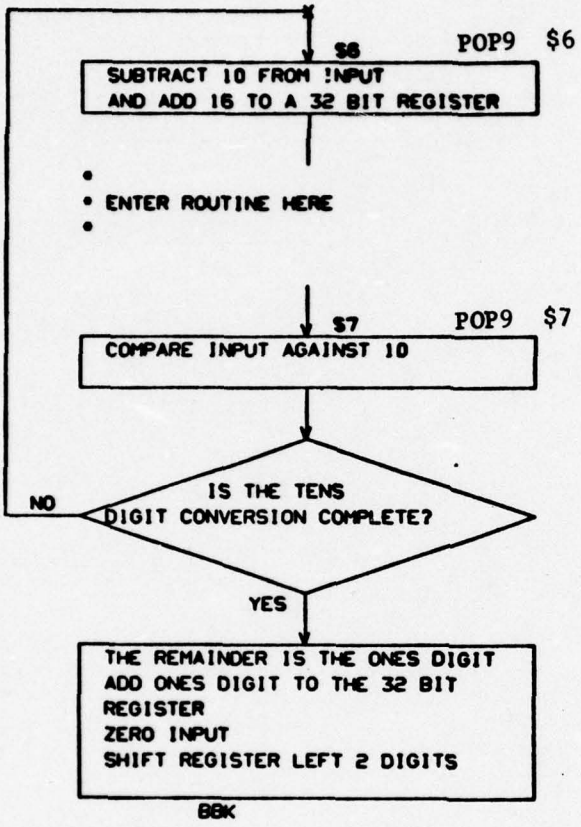
```
•
•                    BCD TO BINARY
•
• THIS ROUTINE WILL CONVERT 2 BCD CHARACTERS TO BINARY.  THE ARGUMENT
• IS A 32 BIT WORD WITH THE 2 DIGITS IN THE MOST SIGNIFICANT BITS.  THE
• ARGUMENT IS SHIFTED LEFT END AROUND ON RETURN
•
```



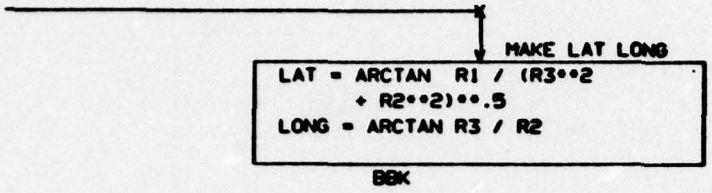
```
•                    LATITUDE / LONGITUDE SCALING
•
• THIS ROUTINE TAKES LAT AND LONG THAT HAS BEEN CONVERTED TO BINARY AND
• CHANGES IT TO RADIANS SCALED PI AFTER CORRECTING FOR S LAT AND W LONG
•
```



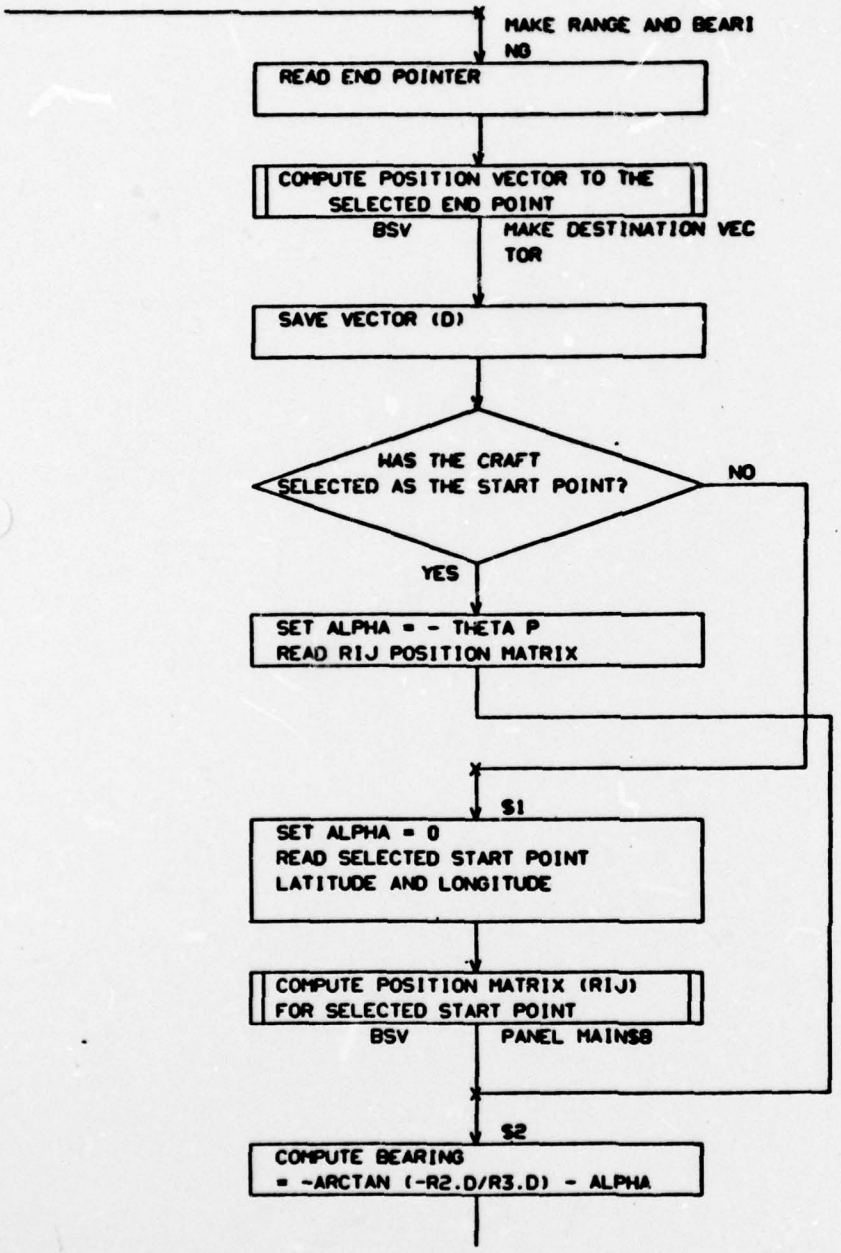
```
•                    BINARY TO BCD
•
• THIS ROUTINE WILL CONVERT A BINARY NUMBER (LESS THAN 100) SCALED B15
• TO TWO BCD CHARACTERS THAT ARE PLACED IN THE 2 LOW DIGITS OF A 32 BIT
• REGISTER AND THEN SHIFTED LEFT 2 DIGITS.  THE ARGUMENT IS SET TO ZERO.
•
```

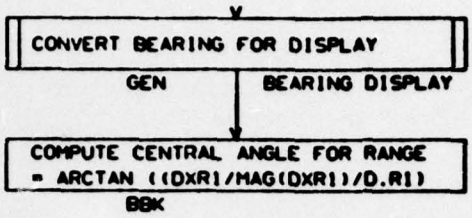


```
•                    MAKE LAT LONG
•
• THIS ROUTINE WILL COMPUTE LATITUDE AND LONGITUDE FROM A POSITION
• VECTOR.  THE ARGUMENT CONSISTS OF A POINTER TO THE VECTOR
•
```



```
•                    MAKE RANGE AND BEARING
•
•THIS ROUTINE WILL COMPUTE THE RANGE AND BEARING BETWEEN 2 POINTS AND
• CONVERT THE BEARING FOR DISPLAY.  THE ARGUMENTS CONSIST OF POINTERS
• TO THE SELECTED DESTINATIONS (13 INDICATES THAT THE CRAFT IS TO BE
• USED AS THE START POINT).
•
```

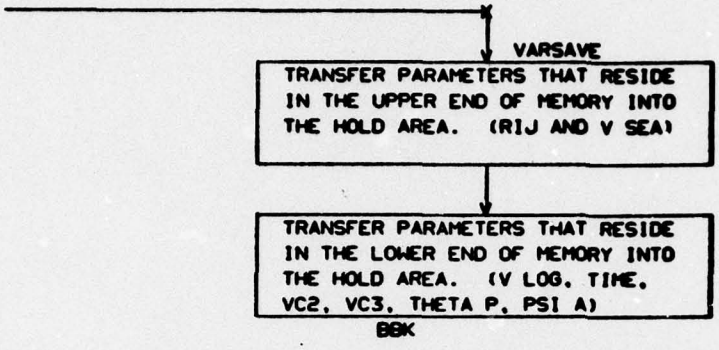



CONVERT BEARING FOR DISPLAY
GEN
BEARING DISPLAY
COMPUTE CENTRAL ANGLE FOR RANGE
= ARCTAN ((DXR1/MAG(DXR1)/D.R1)
BBK

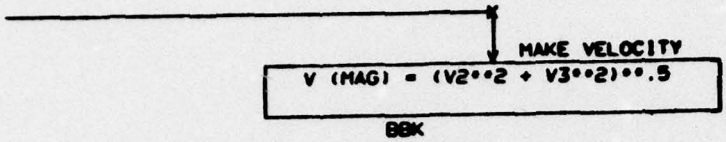
•

VARSAVE

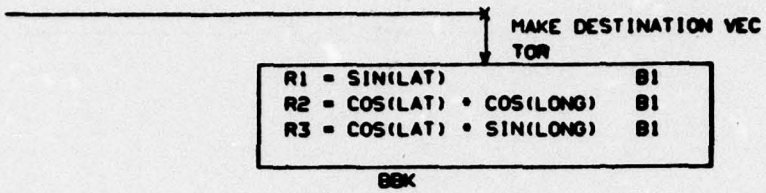
• THIS ROUTINE TRANSFERS THE CRAFT RELATED DATA USED BY THE VARIOUS
• DISPLAY PROGRAMS INTO A SPECIAL STORAGE AREA. THIS TRANSFER DOES NOT
• OCCUR DURING THE HOLD MODE
•



```
•                    VELOCITY MAGNITUDE
•
•
• THIS ROUTINE COMPUTES THE MAGNITUDE OF THE TWO ELEMENT VELOCITY
• VECTOR ARGUMENTS
•
```

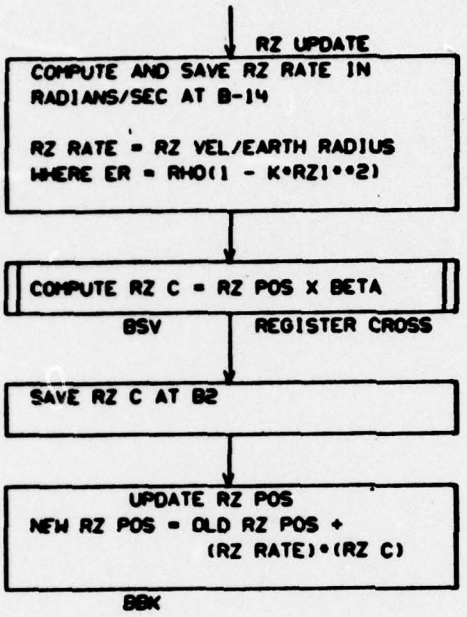


```
•                          POSITION VECTOR
•
• THIS ROUTINE COMPUTES A 3 ELEMENT POSITION VECTOR FROM LATITUDE AND
• LONGITUDE ARGUMENTS
•
```

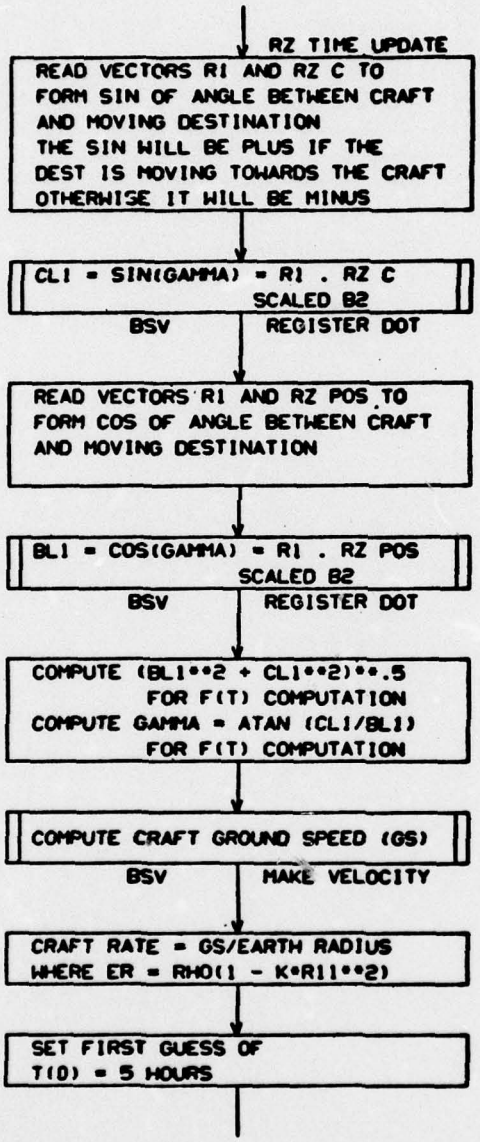


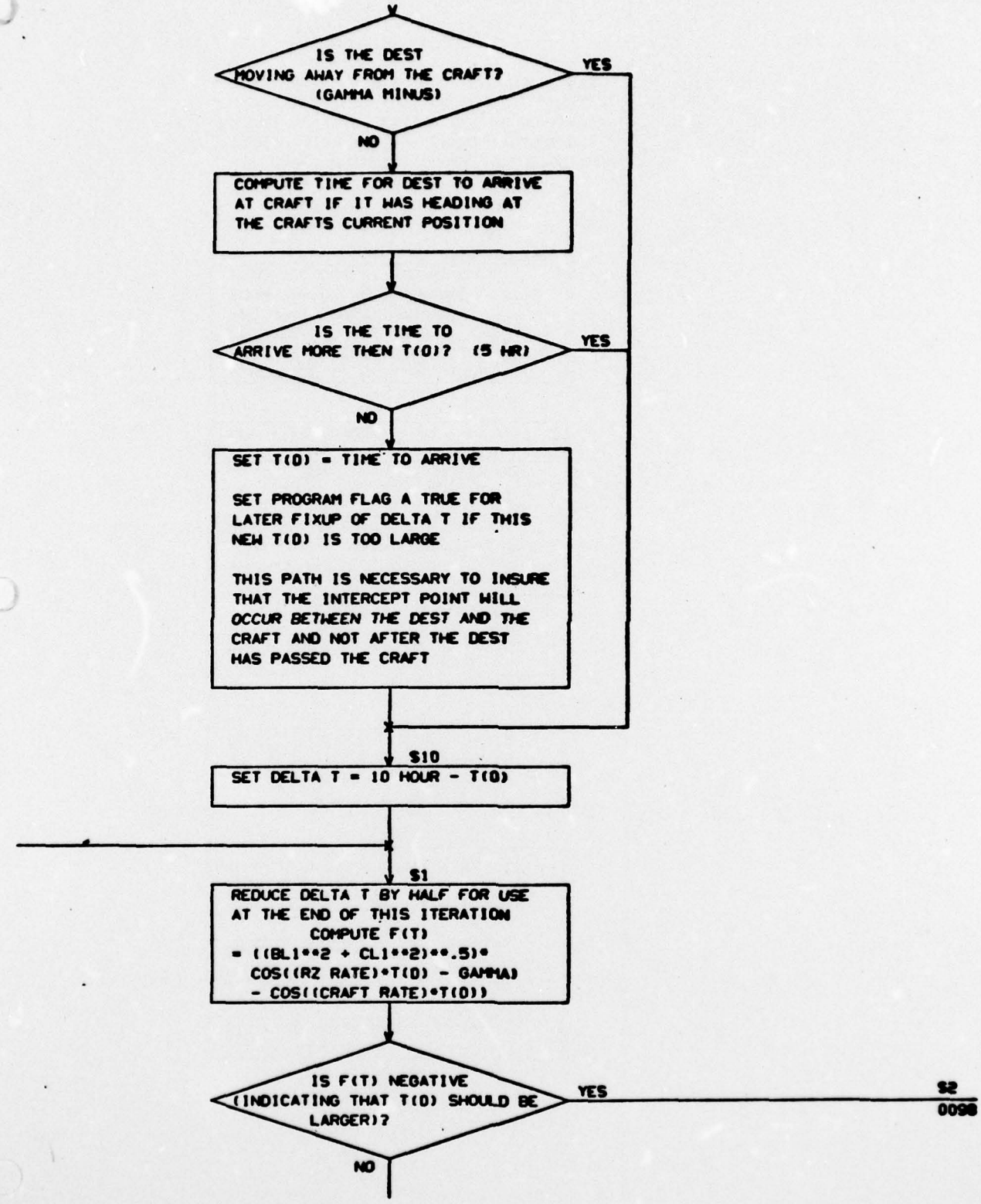
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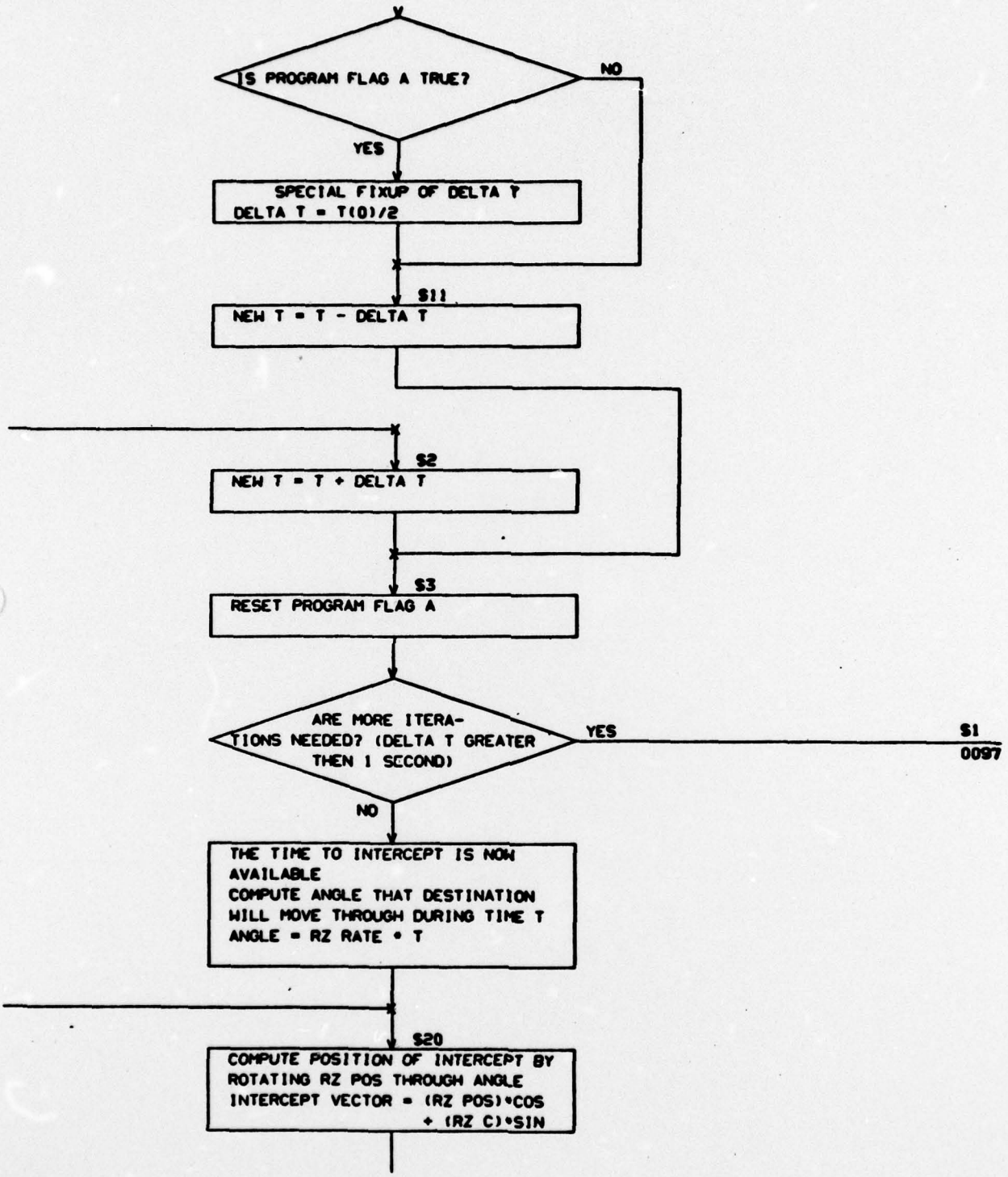

```
•          RZ POSITION UPDATE
•
• THIS ROUTINE IS A SLOW NON OMEGA TASK
• (ONCE PER SEC) THAT UPDATES THE MOVING
• DESTINATION POSITION
```

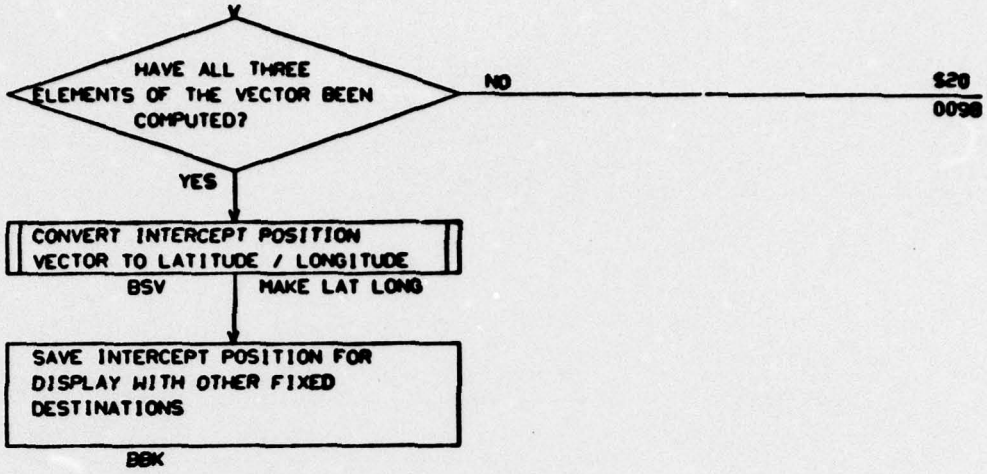


```
•          RZ TIME UPDATE
•
• THIS ROUTINE IS A SLOW NON OMEGA TASK
• (ONCE PER SEC) THAT DETERMINES THE
• POINT OF INTERCEPTION OF THE MOVING
• DESTINATION AND THE CRAFT (ASSUMING
• THE CRAFT CHANGES COURSE TO THE OPTIMUM
• HEADING)
```




IS THE DEST MOVING AWAY FROM THE CRAFT? (GAMMA MINUS)
YES
NO
COMPUTE TIME FOR DEST TO ARRIVE AT CRAFT IF IT HAS HEADING AT THE CRAFTS CURRENT POSITION
IS THE TIME TO ARRIVE MORE THEN T(0)? (5 HR)
YES
NO
SET T(0) = TIME TO ARRIVE
SET PROGRAM FLAG A TRUE FOR LATER FIXUP OF DELTA T IF THIS NEW T(0) IS TOO LARGE
THIS PATH IS NECESSARY TO INSURE THAT THE INTERCEPT POINT WILL OCCUR BETWEEN THE DEST AND THE CRAFT AND NOT AFTER THE DEST HAS PASSED THE CRAFT
$10
SET DELTA T = 10 HOUR - T(0)
$1
REDUCE DELTA T BY HALF FOR USE AT THE END OF THIS ITERATION
COMPUTE F(T)
= ((BL1**2 + CL1**2)**.5)*
COS((RZ RATE)*T(0) - GAMMA)
- COS((CRAFT RATE)*T(0))
IS F(T) NEGATIVE (INDICATING THAT T(0) SHOULD BE LARGER)?
YES
$2
0098
NO


IS PROGRAM FLAG A TRUE?
NO
YES
SPECIAL FIXUP OF DELTA T
DELTA T = T(0)/2
$11
NEW T = T - DELTA T
$2
NEW T = T + DELTA T
$3
RESET PROGRAM FLAG A
ARE MORE ITERA-
TIONS NEEDED? (DELTA T GREATER
THEN 1 SECOND)
YES
$1
0097
NO
THE TIME TO INTERCEPT IS NOW
AVAILABLE
COMPUTE ANGLE THAT DESTINATION
WILL MOVE THROUGH DURING TIME T
ANGLE = RZ RATE * T
$20
COMPUTE POSITION OF INTERCEPT BY
ROTATING RZ POS THROUGH ANGLE
INTERCEPT VECTOR = (RZ POS)*COS
+ (RZ C)*SIN


HAVE ALL THREE ELEMENTS OF THE VECTOR BEEN COMPUTED?
NO
S20
0098
YES
CONVERT INTERCEPT POSITION VECTOR TO LATITUDE / LONGITUDE
BSV
MAKE LAT LONG
SAVE INTERCEPT POSITION FOR DISPLAY WITH OTHER FIXED DESTINATIONS
BBK

3.3 COMPUTER SUBPROGRAM ENVIRONMENT

3.3.1 Control and Indicator Tables

a) Accept Insert Table - This table is used to point to the selected routine to process the inserted data. It is described in detail in the flow charts (Page 2) and in the listing. The official name of this table is PANEL MAIN$1. There is an entry in the table for each panel keyboard button that defines a legal insert.

b) Start Procedure Table - This table is used to point to the selected routine to initiate a procedure. It is described in detail in the flow charts (Page 50) and in the listing. The official name of this table is PANEL INPUT$2. There is an entry in the table for each panel button that is not considered part of the main keyboard (lower fifteen button).

c) Display Procedure Table - This table is used to point to the selected display procedure routine. It is described in detail in the flow charts (Page 53) and the listing. The official name of this table is DISTART$10. There is an entry in the table for each panel keyboard button that defines a legal display.

d) Insert Procedure Table - This table is used to point to the selected insert procedure routine. It is described in detail in the flow charts (Page 59) and the listing. The official name of this table is INSACC$7. There is an entry in the table for each panel keyboard button that defines a legal insert except for POS.

e) Display Generation Table - This table is used to point to the routine to generate the selected display. It is described in detail in the flow charts (Page 17) and the listing. The official name of the table is PANELOUTPUT$4. There is an entry in the table for each panel keyboard button that defines a legal display.

f) Wait for Button Table - This table points to the routine that set up for the next button in a procedure. There are twelve of these routines and the argument to the PANEL PIN routine determines which of the twelve is to be entered. An argument of one would select the first entry. Three of the twelve routines are also used to exit the PANEL INPUT interrupt routine. Their returns are saved in the PROC linkage for use after the next keyboard button is depressed. The other nine routines are called the ACCEPT GROUP and do not exit the PANEL INPUT interrupt routine. Their returns are saved in the LINK linkage for use at the end of the selected routine. The seven entries for the ACCEPT GROUP must be the last seven entries in the table. The official name of this table is PANEL PIN TABLE. It is described in the flow charts (Page 67) and the listing.

g) Cumulative Days by Month Table - This table is used to convert the current month to days in the year or to determine the current month from the number of days in the year. The table has 13 entries to run from January to January. Each entry is the number of days from the beginning of the year to the beginning of the month assuming that it is not leap year. This table is defined in detail in the listing. Its official name is DAYS BY MONTH.

h) Position Quality - This table is used to convert the A, B or C position quality to a variance for KALMAN. This table is defined in detail in the listing. The variances are in units of square radian scaled B-6. The entries can be defined in nautical miles and converted to the appropriate units in the listing. The official name of this table is POS NOISE TABLE.

3.3.2 Temporary Storage

The control and indicator program uses 12 words of temporary storage (called BEARING TEMPS) in addition to words placed in the R15 pushdown stack. The BEARING TEMPS are only used by the MAKE RANGE AND BEARING subroutine in the control and indicator program.

3.3.3 *Input/Output Formats*

The discussion of Input/Output formats is covered in Section 3.2.3.3 of Volume I, Submarine Omega Computer Program Performance Specification.

3.3.4 Required System Library Subroutines

Subroutine	Flow Diagram		Subprogram Design Document (by Volume No.)
ATAN	P13/2	P88/1	All subroutines in Volume XII
	P19/$21	P89/$2	
	P45/POP13	P96/5	
	P46/POP14	P99/2	
CROSS PRODUCT	P90/2	P45/2	
D PHI KI	P27/1	P38/$2	
DOT PRODUCT	P89/$2	P96/2	
	P90/2	P96/4	
POSITION MATRIX COMPUTATION	P12/6		
RESOLVE	P94/2		
SIN COS	P12/6	P89/2	
	P13/3	P89/7	
	P14/2	P93/1	
	P15/$91	P97/6	
SQRT	P13/2	P46/3	
	P15/$91	P88/1	
	P19/$21	P92/1	
	P20/$1	P96/5	
	P23/$1	P96/6	
	P25/3	P97/$1	
	P43/1	P99/2	